AUG 4 1923

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, p. 35; and 24-25 last week.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

For Immediate Sale:—
All-Geared "Bullard" Type VERTICAL BORING AND TURNING MILL Chuck 34 in. diameter, will swing 40 in., capstan head, cross travel 34 in., vertical travel 20 in., gear-box drive, new condition.
One 18 in. stroke SLOTTING MACHINE, Table 35 in. diameter, travel 2 ft. 6 in. by 1 ft. 8 in., makers, Smith & Coventry; modern, equal new.
Twenty Gap Bed S.S.S.C. LATHES, from 4½ in. to 10 in. centres, hollow spindles; modern and in equal to new condition.
Low prices will be accepted for immediate clearance. Seen Glasgow.
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The Strongest Chain in the World.
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Specification and Workmanship equal to Main Line Locomotives.
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PATENT BOILERS. *See page 76, July 13.* 1203
Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Æ Tubes, Plates, Rods, &c.,
in Brass and Copper.
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Slightly Defective, STEEL F.B. RAILS, 60lbs. per yard, and FISHPLATES.—THOS. W. WARD, LTD., Sheffield. B 48

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Duckham's Patent Suspended
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Cochran MULTITUBULAR AND CROSS-TUBE TYPES **Boilers.**
See page 17, July 13. 1124

The Mitchell Conveyor and
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DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
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See's Patent Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

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TUTORS, 254, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 969

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Tubes and Fittings.
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 67.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, } Row's PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

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Tubes AND Fittings AND Steel Plates.

STEWARTS AND LLOYDS, Ltd.
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See Advertisement, page 96. 1111

Drag Line Excavator.
Has moved 2,000 cube yards in one day. May be seen at Frodsham, near Chester. Reach 77 ft.; lift four to five tons; speed of working, one to three cuts a minute.
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&c., &c. 1586

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DRAWINGS, TRACINGS, etc. Prepared for all kinds Engineering work. Patent Drawings.
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1445

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1120
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LIMITED.
See Advertisement page 58, July 13. 2402

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SPECIAL MACHINERY, try—
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W. 11.
Est. 1854. 1484

Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
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See advertisement alternate weeks. 9335

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FELLOWS BROS., LTD., 9168
CRADLEY HEATH, STAFFS.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 1312

WAYGOOD-OTIS LIFTS 1415
54 & 55, FETTER LANE, LONDON, E.C.4, 62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

PRESSINGS, STAMPINGS,
for all Trades,
Fyfe, Lumsden Ltd.,
Eccles, Manchester.
Tel.: 884 Eccles. 1568

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
929
See half-page Advertisement, page 67, July 6.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
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COMPLETE COURSES OF STUDY, extending over either three or four years, are arranged in CIVIL, MECHANICAL and ELECTRICAL ENGINEERING for the Engineering Degrees of the University of London, and for the Diploma and Certificate of the College.

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Considerable Extensions have been made in the Engineering Department. These include a large additional drawing-office, lecture room, and laboratory for Hydraulics and Strength of Materials in the Civil and Mechanical Departments; and research rooms, including Wireless Telegraphy, in the Electrical Engineering Department. Large additions have been made to the equipment of the Laboratories in the three Departments for purposes of teaching and research.

There is a College Hostel and a large Athletic Ground.

For full information apply to the SECRETARY, King's College, Strand, W.C. 2. B 105

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.E.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, TRAFFORD CHAMBERS, 55, SOUTH JOHN STREET, LIVERPOOL. 1295

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1567

TENDERS.

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

1650 STEEL TYRES.

Specification and Form of Tender can be obtained at the Company's Offices, 133, Gresham House, Old Broad Street, London, E.C. 2., on or after 18th July, 1923.

A fee of £1 1s. will be charged for the specification, which is not returnable.

Tenders must be submitted not later than NOON on Wednesday, 1st August, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. B 125

FUEL ECONOMISERS.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive

Tenders before Eleven

a.m. on Wednesday, 8th August, 1923, for the SUPPLY and ERECTION of FUEL ECONOMISERS at the P.O. Telegraph Factory, Birmingham.

Drawings, Specifications, and Forms of Tender may be obtained from the Contracts Branch, H.M. Office of Works, King Charles Street, London, S.W. 1, on payment of One Guinea. (Cheques payable to The SECRETARY, H.M. Office of Works). The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. B 139

IRISH FREE STATE.

HAULBOWLINE DOCKYARD.

The Government of the Irish Free State are prepared to consider

Offers for the Lease of the

above NAVAL DOCKYARD, situated at the entrance to Cork Harbour, and containing extensive Wharf and Warehouse accommodation, with large Dry Dock and Slip-ways. The yard is provided with 60-ton Shear Legs, Travelling Cranes, and well-equipped Machine Shops.

Specifications, Drawings and particulars may be obtained from

J. F. CROWLEY & PARTNERS,
Consulting Engineers,
16, Victoria Street,
Westminster.

Offers, which should indicate the employment that would be afforded, should reach the above not later than August 26th. The Government do not bind themselves to accept the highest or any Offer. B 120

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

815 CAST STEEL AXLEBOXES.

Specification and Form of Tender can be obtained at the Company's Offices, 133, Gresham House, Old Broad Street, London, E.C. 2, on or after 16th July, 1923.

A fee of £1 1s. will be charged for the specification, which is not returnable.

Tenders must be submitted not later than NOON on Tuesday, 31st July, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. B 110

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

(1) VOLUTE SPRINGS.
(2) BUFFER PLUNGERS & CASES.

Specifications and Forms of Tender can be obtained at the Company's Offices, 133, Gresham House, Old Broad Street, London, E.C. 2, on or after 19th July, 1923.

A fee of £1 1s. will be charged for each Specification, which is NOT returnable.

Tenders must be submitted not later than NOON on Thursday, 2nd August, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. B 142

TYNE IMPROVEMENT COMMISSION.

TENDERS FOR WASTE HEAT BOILER.

THE TYNE IMPROVEMENT COMMISSIONERS are prepared to receive

Tenders for the Supply and

ERECTION of a WASTE HEAT BOILER for their Repairing Yard, Howdon-on-Tyne.

Copies of the Form of Tender, Conditions of Contract and Specification may be obtained on application to the undersigned, on payment of a deposit of £1, which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes, endorsed on the cover "Tender for Waste Heat Boiler" must be addressed to the undersigned and delivered not later than Noon on THURSDAY, 2nd AUGUST, 1923.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
RICHARD AUGHTON,
General Manager.

Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
17th July, 1923. B 134

SALFORD BOARD OF GUARDIANS.

Union Infirmary, Stott Lane, Pendleton, near Manchester.

The Guardians invite

Tenders for New Lancashire

BOILER, ECONOMISER, FEED PUMPS, STEAM and WATER PIPES, etc., in connection with the Laundry and extensions to the heating and hot water system at the Union Infirmary.

Drawing of the plant and detailed specification of the new boiler may be inspected at the offices of the Engineer, Mr. T. ROLAND WOLLASTON, M.I.Mech.E., Lord's Chambers, 26, Corporation Street, Manchester. Form of Tender, General Specification and Conditions of Contract may be obtained from me on receipt of cheque for Two guineas, which will be refunded upon receipt of *bona fide* Tender.

The Guardians do not bind themselves to accept the lowest or any Tender, and the selected Contractor will be required to subscribe to the Conditions as regards employment of labour, etc., as set forth in their regulations.

Sealed Tenders endorsed "Engineering, Section 1," must be delivered at my offices not later than Ten a.m. on Saturday, August 4th, 1923.

By Order,
E. H. INCHLEY,
Clerk to the Guardians.

Poor Law Offices,
Eccles New Road,
Salford.
17th July, 1923. B 129

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby In-

vited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to :—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

SPECIFICATION No. 23/117—
22,000 VOLT INSULATORS.

CHARGE :—£2 2s. for the first three copies of Tender Form, Conditions of Contract, Specification, complete. These charges will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each.

PRELIMINARY DEPOSIT :—A Preliminary Deposit of £50 is to be lodged with the Tender.

The Specification may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned, in Melbourne, not later than Noon on 6th October, 1923.

R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. B 123

THE MINISTRY OF PUBLIC WORKS, EGYPT, Is calling for

Tenders for the Supply of a

12 in. HYDRAULIC DREDGER and TUG for the Ibrahima Canal. Copies of Specification and Tender Form can be obtained from :—

THE INSPECTING ENGINEER,
Egyptian and Sudan Governments,
Queen Anne's Chambers,
Westminster,
S.W. 1. B 150

CORPORATION OF GREENOCK, ELECTRICITY DEPARTMENT.

Offers are Invited for the

ERECTION of OVERHEAD TRANSMISSION LINES between—

(1) Greenock Electricity Power Station, Dellingburn, Greenock, and the Electricity Power Station, Blackhall Street, Paisley: and
(2) the existing transmission lines belonging to the Burgh of Kilmarnock, near Beith, and the said Power Station at Paisley.

Plans may be seen at the Office of Mr. F. H. WHYSALL, M.I.E.E., Burgh Electrical Engineer, Dellingburn Power Station, Greenock, where specifications and schedules of quantities may be obtained on a deposit of £2 2s. 0d., for each schedule. The deposit will be returned to contractors who make a *bona fide* offer.

Sealed Tenders, endorsed "Offers for Transmission Lines" must be lodged with the subscriber on or before Saturday, 18th instant, at Ten a.m.

The lowest or any offer may not be accepted.

ANDREW NIMMO, Town Clerk.
Municipal Buildings,
Greenock, 11th July, 1923. B 91

BY ORDER OF THE RECEIVER.

For Sale by Public Tender,

subject to conditions which are attached to the Printed Particulars of Sale.

THE WORKS, PLANT, EQUIPMENT, STOCK AND BUSINESS
of
THE UNITED BRASSFOUNDERS AND ENGINEERS LIMITED.
comprising

Several Model Works recently laid out or modernised for the efficient production of valves, taps, gauges, plumbers' fittings and various brasswork, viz.:

LOT 1.

ORMSKIRK, LANCASHIRE.—Recently erected freehold Factory about 8400 sq. yds. floor space, including handsome administrative block and vacant land for large extensions, Seven Dwelling-houses (Three Freehold and Four Leasehold) and Excellent Equipment of Machine Tools, Foundry and Rodding Plant, Loose Tools, Patterns, &c., Electric Power and Lighting generated from own Gas Engines.

LOT 2.

HALIFAX, YORKSHIRE.—Modern Works about 7400 sq. yds. floor space, with Offices and Canteen. Valuable well laid out Machine Tools and Foundry Plant, Loose Tools, Patterns, &c. Electric Power and Lighting from Corporation.

LOT 3.

WOODCHESTER, GLOUCESTERSHIRE.—Excellent Works, mainly erected from 1916 to 1919, with Offices and Canteen, Six Cottages, Modern Automatic and other Machines for brass and iron taps, Semi-rotary Pumps and Gauges, Foundry Plant, Loose Tools, Patterns, &c. Electric Driving from own Gas Engines and Efficient Water Turbines.

LOT 4.

BIRMINGHAM.—Central premises in Holloway Head, containing about 4500 sq. yds. floor space, including Foundries, Electric Driving, Machines and Equipment for manufacturing plumbers' brass work, sprays, &c.

LOT 5.

MANCHESTER.—Modern premises in Empress Street, Stretford, principally one lofty storey; floor area about 7200 sq. yds. but could be increased by adding floors in certain buildings very suitable for the purpose, extensive Offices and Canteen, Electric Power and Lighting from Council or own Gas Plant. Over 120 Machine Tools and other Plant, 10 Ton Three Motor Crane, Patterns for air compressors, steam traps, pumps and valves.

(This branch has been closed down and will not be sold as a going concern).

LOT 6.

The Goodwill of the business with the Trade Marks.

The Stock-in-Trade at the respective Works, consisting mainly of valves and taps and plumbers' brass fittings; Work in Progress and Raw Materials.

The Receiver is carrying on the business (other than that at Manchester, which has been closed), and the purchaser or purchasers must take over all existing contracts.

Offers may be made as follows :—

(A) For the whole of the properties, stock, goodwill, trade marks and business as a going concern (other than cash, book and other debts, bills receivable, investments and claims for repayment of taxes).
(B) For any one or more of the properties.
(C) For the Trade Marks and Goodwill.

The Offers to be made on a specified form attached to the Printed Particulars and Conditions, and must be delivered to the Receiver at his Offices, 4, Central Buildings, Westminster, London, S.W. 1, not later than Twelve o'clock Noon on the 10th day of August, 1923, envelope to be marked "Tender—The United Brassfounders & Engineers Ltd."

The Receiver does not bind himself to accept the highest or any Tender.

Particulars of the Land, Ground Rents and other information, Plans of the Buildings, and permits to view the properties, may be had from the Solicitors or Valuers.

Printed Particulars with Conditions and Form of Tender may be had from—

M. WEBSTER JENKINSON, Esq.,
Receiver,
4, Central Buildings,
Westminster,
London, S.W.1.
Messrs. LINKLATERS & PAINES,
Solicitors,
2, Bond Court,
Walbrook,
London, E.C.4.
Messrs. F. S. AIREY, ENTWISTLE & CO.,
Auctioneers, Valuers & Fire Loss Assessors,
10, Norfolk Street,
Manchester. B 128

The Director-General,

INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, requires :—

CARRIAGE UNDERFRAMES.

Tenders due on the 10th August, 1923.
Tender Forms obtainable from above. B 115

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of

the following STORES, namely :—

		Fee for Specification.
1.	Canvases, &c.	10/-
2.	Steel Screw Couplings, &c.	£1
3.	Steel Drawbars for Wagons	£1
4.	Rolled Steel Discs or Spoke Wheels and Axles (forgings) for Carriages and Wagons	£1
5.	Spare parts of Locomotive Engines	10/-
6.	Axle-boxes for Carriages and Wagons	10/-

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Canvases," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 31st July, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 18th July, 1923. B 145

APPOINTMENTS OPEN.

Sales Manager, having similar

experience, REQUIRED by old established lubricating oil and motor spirit firm of high repute. Applicants to submit qualifications.—Write, BOX "G.H.," c/o DAVIES & Co., 95, Bishopsgate, E.C. 2. B 143

Wanted, Outside Shipyard

MANAGER for Shipyard, operating four Berths in the Western District. Candidates must have good experience of Passenger and Oil Tanker Work. They should furnish testimonials and state age, experience and salary required.—Address, B 107, Offices of ENGINEERING.

Works Manager

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THE LAWS OF HEAT TRANSFER.

(*Continued from page* 3.)

IN the preceding article it was noted that when a fluid in turbulent flow traverses a pipe, there is always a film, which creeps along the wall of the pipe, and which on the average takes no part in the turbulence. The boundary between this film in viscous flow and the turbulent core is probably far from absolutely definite. At any given place, the thickness may vary from moment to moment, but there is a certain average thickness which we shall denote by f. As already stated most of those who have discussed this film have assumed that the relation between f and d, where d is the diameter of the pipe could be expressed in the form

$$\frac{f}{d} = \left(\frac{\mu}{\rho v d}\right)^n$$

where μ denotes the viscosity of the fluid, ρ its density and v its mean velocity, whilst n is a positive fraction.

Such a formula implies that f is infinitely great when d becomes infinite, or in other words, according to this formula, the viscous film covering the surface of a smooth flat surface towed through water would be infinitely great.

It would seem therefore that this type of formula is irrational, and it is of interest to try to obtain some hint as to how it can be improved by considering the physical nature of turbulent flow.

Experiment shows that in the turbulent flow of a fluid through a pipe the curve representing the velocity at different points of the stream has the form indicated in Fig. 3, whilst in viscous flow the corresponding curve is a parabola as shown. The two curves in the figure are calculated for one and the same friction loss. It is suggestive to regard turbulent flow as originating in a passion for equality amongst the fluid particles. In capillary tubes the favoured individuals which occupy the centre of the pipe, progress twice as fast as the average. When the average rate of progress exceeds a certain limit, however, there is a protest on the part of the majority against this inequality of opportunity, and the favoured molecules are displaced from the central position by others only to be ousted in their turn. The net result is that for a given intensity of strain on the "under dogs" which are represented by the particles immediately adjacent to the tube wall and which remain there, the average progress effected for a stated expenditure of energy is only a small fraction, of what it would have been, had not the orderly regime, characteristic of viscous flow, been replaced by a turbulent condition.

Perfect equality in the rate of progress of the particles constituting the turbulent core is not, however, established. At any given moment the particles at the centre of the pipe are progressing some 20 to 25 per cent. faster than the average. In order to get a hint as to the thickness of the viscous film, let us assume that the levelling aspirations of the insurgent particles are completely satisfied so that in this "ideal" turbulent flow, the velocity curve has the form represented in Fig. 4 by A B C D, where the portion F B C E represents the "ideal" turbulent core and G B or C H the corresponding thickness of the viscous film. In actual practice, of course, the corners at B and C are rounded off, so that the real thickness of the film must be less than G B. We thus get an upper limit to the possible thickness of the viscous film, and can express the actual thickness as some fraction of this ideal thickness, which can be readily calculated from the theory of the viscous flow of fluids.

The conditions of the problem are that the resistance to the flow is the same as in the practical case and the mean velocity the same. The curves A B and D C are portions of a "viscous" parabola such as that represented in Fig. 3.

By Professor Lees' formula we can calculate the actual wall friction corresponding to ordinary turbulent flow. Calling this F we can determine from F the dimensions of the "viscous parabola" and to find the value of G B, that is to say, the thickness of the "ideal" film, we have to make the velocity F B such that the total discharge is the same as in the practical case.

Keeping to the C G S system of units for the reasons given on page 2 *ante*, let F denote the frictional resistance per square centimetre of the wall surface. Then in a length of pipe Δx the total resistance retarding the fluid will be $F \times \pi d \times \Delta x$.

Let P be the pressure in dynes per square centimetre at the commencement of the short length of pipe under consideration. Then the total force urging the fluid forward is $P \times \frac{\pi d^2}{4}$.

At the end of the short length Δx we note that by Taylor's theorem the pressure will be

$$P + \frac{dP}{dx}\Delta x$$

plus additional terms depending on higher powers of Δx, which may be neglected. This pressure tends to retard the fluid, exercising on it a force equal to

$$\left(P + \frac{dP}{dx}\Delta x\right)\frac{\pi d^2}{4}.$$

The flow being steady, the velocity of the fluid is the same at both ends of the section. Hence on the whole no force has acted on it, or in other

Fig. 3. FLOW OF FLUIDS IN PIPES. The Wall Friction is the same for both Curves, and it will be seen that could Turbulence be prevented the quantity discharged for the same Loss of Head would be, in this Instance, 9 times as great as it actually is.

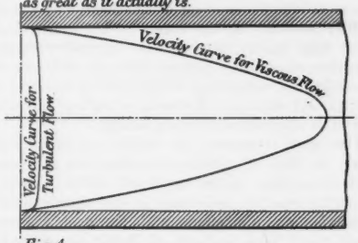
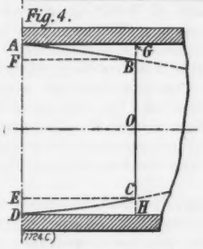


Fig. 4.



words the total accelerating force is equal to the total retarding force. This gives us—

$$P\frac{\pi d^2}{4} = \left(P + \frac{dP}{dx}\Delta x\right)\frac{\pi d^2}{4} + F \cdot \pi d \cdot \Delta x.$$

Whence we get—

$$\frac{dP}{dx} = -\frac{4F}{d}. \quad . \quad . \quad . \quad (A)$$

Now in the case of viscous flow there are no cross currents in the pipe, and the direction of motion is everywhere parallel to the axis. In other words the velocity of the fluid at any point depends only on its distance from the centre, that is to say on the radius of the point at which it may be measured. The equations to the viscous flow of a fluid were established in full detail from elementary principles in an article published in ENGINEERING in July 30, 1915, page 101. We only require one of these equations here, viz.,

$$\frac{dP}{dx} = \mu \nabla^2 u$$

where u is the velocity of flow at any point of the cross section and μ the viscosity in C G S units, whilst the axis of the pipe is taken as the axis of x.

If we adopt polar co-ordinates and note that u depends only on the radius at which the particle considered is situated, we have

$$\nabla^2 u = \frac{1}{r}\frac{d}{dr}\left(r\frac{du}{dr}\right)$$

Hence

$$\frac{dP}{dx} = \frac{\mu}{r}\cdot\frac{d}{dr}\cdot\left(r\frac{du}{dr}\right)$$

But from (A) we have

$$\frac{dP}{dx} = -\frac{4F}{d}.$$

On equating these two values and integrating the resulting expression, we get:—

$$u = \frac{1}{\mu}\left(A - \frac{F}{d}\cdot r^2 + C\ \log r\right)$$

where A and C are the constants of integration.

Since u is not infinite when $r = o$ or in other words since the velocity along the axis of the tube is always finite, it is evident that the constant C must be zero, which gives us—

$$u = \frac{1}{\mu}\left(A - \frac{F}{d}r^2\right) \quad . \quad . \quad . \quad (D)$$

Experiment has shown that in the motion of fluids over surfaces there is in general no slip at the boundary. A particle which touches the wall at any point can, in short, only get away from that point by the slow process of diffusion, a phenomenon with which we are not concerned here. Since every fluid particle in contact with the pipe wall is at rest, the velocity of flow at this surface is zero, hence we can determine the value of the constant A in equation (D) by putting $u = 0$ when $r = \frac{d}{2}$. We thus get

$$A = \frac{F}{d}\cdot\frac{d^2}{4} = \frac{Fd}{4}$$

and thus—

$$u = \frac{Fd}{4\mu}\cdot\left[1 - 4\cdot\left(\frac{r}{d}\right)^2\right]$$

It will be found convenient to replace d by $2a$, where a denotes the internal radius of the pipe. Making this substitution we get—

$$u = \frac{F}{2\mu a}\left(a^2 - r^2\right) \quad . \quad . \quad . \quad (C)$$

This shows that the velocity curve for viscous flow is a parabola as drawn in Fig. 3.

Let B denote the radius O B in Fig. 4 so that $a - B$ is the thickness of the ideal film. Consider a thin ring of fluid in this film of which the radius is r and the thickness dr. Then the flow passing through this elementary ring per second is

$$2\pi r\,.\,dr \times u = \frac{\pi F}{\mu a}\,.\,(a^2 - r^2)\,r\,dr$$

and the total flow through the film is therefore

$$\frac{\pi F}{\mu a}\int_B^a (a^2 r - r^3)\,dr = \frac{\pi F}{\mu a}\cdot\left[\frac{a^4}{4} - \frac{a^2 B^2}{2} + \frac{B^4}{4}\right]$$

The velocity of the central portion is from (C)

$$u_B = \frac{F}{2\mu a}(a^2 - B^2)$$

so that the total flow through it is

$$u_B \times \pi B^2 = \frac{\pi F}{a\mu}\cdot\left(\frac{a^2 B^2}{2} - \frac{B^4}{2}\right)$$

Adding this to the flow through the viscous film we get for the total discharge the expression—

$$\frac{\pi F}{4\mu a}(a^4 - B^4)$$

By the hypothesis from which we started, the total discharge in this ideal case is to be the same as the total discharge in the actual case, which is

$$v \times \pi a^2$$

Equating these two expressions we get

$$B^4 = a^4 - \frac{4a^3 v\mu}{F}$$

$$= a^4\left(1 - \frac{4v\mu}{aF}\right)$$

But $F = \rho v^2 L$, where L is Lees' function (page 3 *ante*). Hence

$$B^4 = a^4\left(1 - \frac{8\mu}{\rho v d}\cdot\frac{1}{L}\right)$$

Hence if f_1 denote the thickness of this ideal film we have $f = a - B$ so that

$$\frac{f_1}{a} = 1 - \left(1 - \frac{8\mu}{\rho v d}\cdot\frac{1}{L}\right)^{\frac{1}{4}} \quad . \quad . \quad (B)$$

This fixes an upper limit to the thickness of the film. As will be evident from Fig. 3, the actual film thickness must always be a fraction of this ideal thickness.

It may be noted incidentally, that we get here a numerical measure of the roughness of a pipe. A pipe is smooth if its "texture" is small compared with f_1. It appears further that a pipe which is "smooth" at small velocities might be "rough" at very high ones.

This formula also fixes a lower limit to the

possibility of turbulent flow. Thus when

$$\frac{\mu}{\rho v d} \cdot \frac{1}{L} = \frac{1}{8}$$

we get $f_1 = a$, and the flow is wholly viscous. In practice, however, turbulence does not come in when this limit is attained, the critical velocity being generally such that

$$\frac{\mu}{\rho v d} \cdot \frac{1}{L}$$

is of the order of $\frac{1}{15}$, so that $\frac{\rho v d}{\mu}$ is about double the lower theoretical limit. This corresponds to a value of $\frac{\rho v d}{\mu}$ = about 2,500.

When d is large we get

$$\frac{f_1}{a} = \frac{2\mu}{\rho v d} \cdot \frac{1}{L}$$

nearly, or

$$f_1 = \frac{\mu}{\rho v} \cdot \frac{1}{L} = \frac{\mu v}{\rho v^2} \frac{1}{L} = \frac{\mu v}{F}$$

This is always finite, however large v or d may be.

Professor Lees states* that his formula for L holds even for surfaces towed through water. Hence it seems fair to assume that the above formula for f_1, also holds good for such surfaces, and that the actual film thickness will in this case also be a fraction of the "ideal" thus calculated.

It should, however, be noted that with flat surfaces towed at a great distance from other surfaces we never get the same type of turbulence as is met with in pipes. In pipes the turbulence fills almost the whole body of the pipe. With flat surfaces immersed in a large body of fluid the turbulence never extends far from the surface itself. The film, however, cannot "know" what is happening at a distance from it. It only "knows" the stresses to which it is subjected, and it seems reasonable therefore to conclude that its thickness should vary with these stresses according to a similar law to that applicable in the case of pipes.

In the next article the endeavour will be made to deduce from Mr. Webster's experiments the coefficient with which the "ideal" thickness of the film calculated as above must be multiplied in order to get the actual film thickness.

(To be continued.)

REINFORCED CONCRETE BRIDGE OVER THE RIVER VESUBIE.

By W. L. SCOTT, Assoc.M.Inst.C.E.

A BRIDGE, which has recently been completed over the River Vesubie, in the South of France, and is now in use, forms an excellent example of the application of reinforced concrete to engineering works of first importance. This is the largest bridge in the world of its class, having a total length of 344 ft. 6 in. and a clear span of 315 ft. The deck platform accommodates a roadway 16 ft. 6 in. wide, with a footpath on either side 3 ft. 9 in. wide, giving a total width to the bridge between parapets of 24 ft. We illustrate this important work in Figs. 1 to 11, on Plates V, VI, and VII published with this issue.

The Var district, in which this bridge is situated, is mountainous and rocky. On one side of the river the roadway is formed by a ledge cut out of the rock running parallel with the river for some distance. The original bridge was carried away by an exceptional flood. Floods are of frequent occurrence and result from the natural conditions obtaining in this part of the country. After the collapse of the older structure a temporary suspension bridge was erected by the military authorities. This bridge was composed of four steel towers, two being at either end of the bridge, with a composite deck of wooden planks and steel girders suspended by steel cables.

When the Bridge and Roads Department of the French Government decided to replace this by a permanent bridge, it was thought that a two-span structure would meet the case and designs were accordingly called for upon this assumption. After these had been prepared, it was, upon further consideration, thought desirable to span the river in such a way that even when the latter was at its highest flood, no part of the structure would be subjected to any possible damage resulting from its rapid flow or floating matter, such as trees being carried down. It was therefore decided that the new bridge should have a clearance above maximum flood level of about 2 ft. Various firms submitted schemes for a single span bridge to meet the conditions specified, and after due consideration a reinforced concrete bridge to the Considère design was selected as the most satisfactory, meeting all the specified conditions. In addition to this the estimated and actual cost of the structure to this accepted design was not greatly different from that submitted for a two-span bridge giving the same accommodation. The actual cost of the bridge, which amounted to 620,000 francs, also compared very favourably with the estimated cost of a steel structure for the same span and to the same specification. This being the case and taking into account the relative cost of maintenance, the reinforced concrete bridge shows a marked economy over any other form of construction.

For a considerable part of the year the actual water-channel of the river is comparatively limited, and the main part of the river bed was available for use where required for constructive work. This was of importance to those responsible for the reinforced concrete construction, as no space was available at one end of the bridge and only a limited amount at the other. This restriction of space was partly due to the natural conditions described above and partly owing to the fact that the road and temporary bridge were required to be maintained without obstruction during the whole period of erection of the new bridge.

The new structure, of which an elevation is given in Fig. 1, although having the appearance of a bowstring girder type of bridge, comprises in reality two parabolic elastic ribs rigidly fixed to mass concrete abutments with the deck suspended from these ribs instead of being supported by columns in the usual manner. The main ribs have been designed with a rise of approximately one-sixth of the span, this rise of course being measured from the springings. The ribs have an average depth of 7 ft. Sections at the springing and crown are given in Figs. 5 and 6. The general arrangement of the various members is very clearly shown in the view of the finished bridge, Fig. 9, on Plate VII.

In a bridge of this size the effects resulting from temperature variations, shrinkage and rib shortening under load, are of the greatest importance and require to be taken very carefully into account in making the necessary calculations.

The deadweight of a bridge of this span provides, of course, by far the greatest part of the total load, the effect of the superimposed live load being insignificant in comparison. For this reason, temporary hinges of the type originally introduced by M. Considère, were adopted in this case. These hinges permit the bridge to be calculated so far as the dead load is concerned, as a statically determinate three-pin arch. In addition, they allow the bridge to settle under its own weight due to compression and shrinkage, without setting up any appreciable undetermined stresses within the rib members. An excellent view of one of the temporary hinges under load is shown in Fig. 3, Plate VI.

The calculated compressive stress on each of the temporary hinges due to the deadweight of the structure amounted to 2,850 lb. per square inch of cross-section. To provide for this stress the concrete was heavily spiralled in accordance with M. Considère's practice for compressive members subjected to considerable load. The total thrust taken by the octagonal hinge shown in the illustration, Fig. 3, amounted to 400 tons. This load was upon the hinge when the photograph reproduced was taken. After the removal or easing of the temporary staging, the hinges were filled in with concrete, thus converting the ribs into hingeless elastic arcs rigidly fixed at their ends. The calculations for the superimposed live loads provide for this latter condition, and also for the expansion and contraction due to periodical variations in temperature, occurring in the ribs themselves. The method of solution adopted in the case of this bridge and others of its type in reinforced concrete, provides one of the most attractive examples of applied mathematics met with in the design of engineering structures.

Distinct from the temperature effects upon the supporting ribs, the variation in length of the deck platform due to rise and fall of temperature has to be taken into consideration and provided for. In calculating the stresses and probable movement due to the above elastic expansion and contraction resultant from variations in temperature, a range of from 11 deg. to 107 deg. F. was allowed for. The movement due to this variation in an uninterrupted length equal to the roadway of the bridge would result in stresses much in excess of those permissible on the materials employed and the introduction of a transverse expansion joint was essential and was accordingly provided. This is shown in Figs. 1 and 7, on Plates V and VI.

This transverse joint cuts the roadway platform and parapets completely in two. It is arranged near one end of the bridge and is placed midway between two of the transverse beams supporting the roadway slab and which connect the suspenders. It is formed with a rebate or notch in plan. This is provided in order to form a key in the longitudinal direction of the deck construction giving the necessary transverse support against lateral movement arising from wind pressure. This expansion joint is only provided in the reinforced concrete work, no interruption being made in the material forming the road surface itself.

The question of wind pressure was serious owing to the peculiar position of the bridge and its somewhat narrow construction and a pressure of 50 lb. per square foot of surface area was allowed for. The total lateral wind force taken to be acting upon the windward girder was calculated as being its net vertical surface area multiplied by the above unit wind pressure. In addition to this figure, there is the wind force resisted by the leeward girder. This amount, however, is somewhat reduced owing to the protection given to it by the windward member, and this pressure was calculated as follows :—

$$\text{Pressure of leeward girder} = b\left(1 - \frac{b}{a}\right),$$

where b = net surface area of a girder and a = the gross area enclosed by the underside of the deck construction and the top surface of the parabolic rib.

The total lateral force taken to be acting on the bridge due to wind is therefore :—

$$P = b\left(2 - \frac{b}{a}\right)p,$$

where p = the maximum unit wind pressure.

The resistance offered by the bridge against this total wind pressure is provided by the deck construction acting as a horizontal girder and the two curved ribs, lattice braced and supported near each end of the bridge by a stiff diaphragm, carried down to the roadway and supported at this level. Fig. 10, Plate VII, illustrates this bracing and end support and shows the headroom provided at this point. The curved braced girder was calculated for its full developed length, but was assumed to be horizontal so far as bending was concerned.

The deck platform was designed and constructed as follows. The short length of roadway on one side of the expansion joint was considered as a cantilever and was rigidly fixed to its adjacent abutment. It was calculated to take the distributed wind load coming upon it in addition to the reaction from the longer portion of the roadway which was assumed to be freely supported at the rebated expansion joint and rigidly fixed at its opposite end. In this manner all the factors which may be regarded as a source of danger in a bridge of this type constructed with concrete were taken care of and all risk of any defects resulting from them nullified.

The loading specified is the standard loading for road bridges laid down by the French Government, This comprises a train of vehicles which are to be considered as following one after another and to occupy a zone of roadway approximately 7 ft. 6 in. wide. A diagram of this rolling load is given in Fig. 8. In addition to this rolling load a live load of 115 lb. per square foot is provided for on the footpaths and also on any portion of the roadway that may be unoccupied by the above vehicles. No addition was made to the above wheel loads to allow for impact, but the working stresses employed for the

* Institution of Naval Architects, see ENGINEERING, June 2, 1916, page 526.

concrete and steel were reduced. The effects of impact upon a structure or upon any individual member forming a part of the structure, are of course dependent upon the relative inertia of the object producing the impact and the inertia of the structure or member subjected to it: in the case of members in reinforced concrete having a span of this size the impact is not a serious item and becomes of less importance as the members under consideration are remote from the point of the load application.

The stress adopted for the steel reinforcement in the ribs and main beam members was 17,000 lb. per square inch and for the deck construction 13,650 lb. per square inch. The concrete was assumed to have a safe working stress in compression of 796 lb. per square inch. The general assumptions universally adopted for reinforced concrete design were employed in the calculation for this structure and the ribs were considered as homogeneous in so far as the application of the elastic theory was concerned. The safe pressure on the rock foundations was taken to be 5½ tons per square foot.

Regarding the construction of the bridge the temporary staging had to be designed with very great care in view of the necessity for absolute rigidity against any movement due to settlement or to possible lateral displacement due to wind pressure when the concrete was being placed. Transverse trestles of timber piling diagonally braced were formed across the bed of the river except in the permanent channel, where, owing to the rapid flow, reinforced concrete sheet piling was employed. The arrangement of this concrete piling is clearly shown in Figs. 2 and 11.

The under-staging was composed essentially of five longitudinal timber trusses resting upon the transverse trestles described above. These trusses were braced in such a manner that each of the vertical suspenders was diagonally strutted from the transverse trestles. In this manner the decking and parabolic ribs were rigidly supported and the possibility of any sag in the temporary staging during the placing of the concrete was prevented. Fig. 2 shows the trestles and longitudinals, in addition to the somewhat elaborate staging necessary for the superstructure. The whole of the temporary staging was of timber with the exception of the two transverse trestles composed of the concrete sheeting previously mentioned.

It was found when setting out this work, that one of the steel towers of the temporary suspension bridge came over a portion of the site required for the mass concrete abutments of the new work, and this presented some difficulty in view of the fact that the temporary bridge had to be maintained intact during construction. In order to support this steel tower while the new abutments were being placed, a heavy reinforced concrete cantilever beam was constructed in such a manner that its weight counterbalanced the overturning moment imposed by the steel tower. Fig. 4 shows this reinforced concrete cantilever beam in position and the exact arrangement employed.

The majority of the plant necessary for the work had to be placed entirely on one side of the bridge owing to the other side being very steep and the small area available being required for the roadway itself. The concrete was accordingly mixed on one end of the bridge and conveyed along it in trucks running on a light track. For the parabolic ribs and the suspenders small mechanical hoists were introduced and the concrete hoisted and placed in the usual manner.

No rendering or plastering was done on this work, the faces, after removal of the shuttering, being rubbed down with soft stone and at the same time washed over with cement grout in a manner similar to that usually adopted in this country. The road surfacing material was composed of ordinary macadam about 8 in. thick, laid over the area required. This thickness of 8 in. was constant, and the necessary transverse camber was formed in the deck slab itself, this member being constructed to the required curve on both its upper and lower faces.

Tests were made upon the completion of the bridge. These consisted of passing backwards and forwards over the bridge two 18-ton traction engines side by side, followed by several lorries each weighing 8 tons. The total rolling load amounted to 100 tons. The maximum recorded deflection was ⅜ in. The absence of any defects in the form of hair cracks resultant from the above deflection indicates that the bridge behaves as a truly elastic structure and that the assumptions made in the design were justified. Moreover, the complete success with which the bridge was constructed shows that the work was carried out with great care and exactitude by the contractors.

Fig. 9, Plate VII, shows the finished structure in elevation and gives a very good impression of its graceful proportions. The consulting engineers for this work were MM. Pelnard, Considère, Caquot and Cie., of Paris, and the contractors were MM. Thorrand and Cie., of Nice.

THE HYDRO-ELECTRIC SUPPLY TO COLWYN BAY.

By T. VAUGHAN HUGHES, A.R.S.M., F.I.C.

THE electricity supply of Colwyn Bay is now obtained from the mains of the North Wales Power Company, the generating and distributing system of which was dealt with in ENGINEERING of June 15 last. This hydro-electric supply, which came into operation in the autumn of last year, has displaced a former steam-driven station. Particular interest attaches to the change-over because the scheme is the first hydro-electric, public supply sanctioned by the Electricity Commissioners under the Electricity (Supply) Acts of 1919 and 1922, and the resident electrical engineer is also the managing engineer of the council's gas undertaking, which should lead to proper co-ordination between the two local public utility services, and suitable allocations of gas and electricity in the area of supply.

Power is transmitted at about 20,000 volts (presently to be raised to 34,600 volts) from the Cwm Dyli hydro-electric station, situate at the foot of Snowden and also from Dolgarrog, in the vale of Conway. The current is delivered through about 24 miles of bare, overhead transmission lines, via Dolgarrog, to the Bron-y-nant static transformer substation situated on the western confines of the Colwyn Bay Urban District Council area of supply. Here, the energy is transformed down to 6,600 volts and conducted through about 2,499 yards of 3-core paper insulated, lead covered, cable, laid in duplicate, to the motor converter station in Ivy Street, situated at about the centre of the district of Colwyn Bay.

The utilisation of the potential water power on the highlands around Snowden was made possible by the removal of the ill-conceived restrictions to the use of bare overhead lines, imposed by the almost panic legislative Acts of 1880 and subsequent years. Although the conception of the scheme to transmit hydro-electric power from Cwm Dyli, on the slopes of Snowdon, must be attributed to two Welshmen, the late Messrs. Gethin Jones and Roberts, who formed a company designated Gwalia, Limited, substantial developments began when the North Wales Power and Traction Company, Limited was formed in 1903. In 1904 this company obtained an Act of Parliament which empowered them, under the Electric Lighting Acts to supply in the counties of Carnarvon, Anglesey, Denbigh and Merioneth. The powers of the Portmadoc, Beddgelert and South Snowdon Railway were also acquired by them.

In the year 1907, the Aluminium Corporation was formed and erected works on the River Conway at Dolgarrog for the electrolytic reduction of aluminium ores and for rolling the metal, &c. Two years later this company acquired certain water rights from the North Wales Power Company, Limited, which culminated in 1918 by the Aluminium Corporation acquiring controlling interest in the company. The amalgamated concerns are now presided over by the same chairman and managing director. In 1916, the Corporation came to an agreement with the Conway and Colwyn Bay Joint Water Board in respect to the supply of potable water from Lake Cowlyd situate to the west of Dolgarrog, by undertaking to erect a new dam and other works to increase the capacity of the lake. The progress which has taken place since 1916 has been helped by the abnormal demand for aluminium during the war and the reopening of pyrites mines in the neighbourhood.

The latest extensions are in accordance with the scheme presented by the North Wales Power and Traction Company, Limited, to, and accepted by, the Electricity Commissioners, following the enquiry held in February, 1921, at Llandudno. The competitive scheme of the Chester Corporation for the supply of electricity to North Wales was rejected after due consideration by the Commissioners. The Commissioners have empowered the North Wales Power Company to serve a "district," under their order, to include the counties of Carnarvon, Anglesey, Denbigh, Flint, Merioneth and Montgomery, and parts of Cheshire and Shropshire—a total area of over 4,000 square miles.

Anticipating the confirmation of the order in its main essentials the North Wales Power Company are actively carrying out extensive schemes. The Cwm Dyli power house, which was erected in 1903 to 1904 was originally designed to supply the slate quarries with hydro-electric power, in place of steam driven plant. It generated and transmitted at 10,000 volts, 3-phase, 50 cycles, making use of the water in Lake Llydaw, 1,420 ft. above O.D. This lake receives the overflow of a smaller and adjacent lake, Llyn Gaslyn. The averge rainfall, taken over ten years in the catchment area of these lakes, is 150 in. The lake being contained in a dormant volcanic vent, is surrounded by the usual saucer-like rim of rock. The latter has been pierced by a 6 ft. diameter tunnel, the outlet of which is 30 ft. below the level of the lake. The inflow to this tunnel is controlled by two 48 in. sluice valves. At the terminal of the tunnel, the water is delivered into two pipe lines, laid side by side, 30 in. in diameter, contracted to 27 in. diameter in the section leading into the power house. The pipe line is 1¼ miles long. In this distance a fall of 1,120 to 1,150 ft. constitutes the hydraulic head. It is considered possible to increase the capacity of the lake from 150 million cubic feet to about 250 million cubic feet by raising the dam.

The generating plant in the power house (about 265 ft. above O.D.) consists of four twin Pelton wheels, each coupled directly to a 12-pole alternator, with its own exciter, rated at 1,000 kw., and one alternator, rated at 1,500 kw. The first four generate at 10,000 volts, 3-phase, 50 cycles and the latest at 4,800 volts between phases. The five machines were supplied by Bruce Peebles, Limited, while the Pelton wheels have been overhauled by Boving and Co. These machines run at 500 r.p.m. New governors of the oil pressure type were supplied by the last named firm. The present capacity of this plant is 5,500 kw. Step-up transformers by Ferranti are installed to raise the voltage either to 10,000, 20,000 or 34,600 for transmission. At the terminals of the older transmission lines, static step-down transformers are installed to reduce the voltage to 550/500 volts, alternating current, for use in the quarries.

The Cwm Dyli works may be regarded as the nucleus of the schemes for the development of the water power resources of North Wales. They are now connected by about 32 miles of overhead transmission lines, through the Dolgarrog power station, in the Vale of Conway, to the secondary transformer substation at Bron-y-nant, in the Colwyn Bay Urban District Council area. The voltage between phases on this line is 20,000 volts, to be raised later, to 34,600 volts, under the order. Thus the first public supply under the provisions of the Electricity Acts of 1919 and 1922, can be furnished either from the Cwm Dyli or the Dolgarrog hydro-electric stations.

The type of overhead transmission line has been standardised. Creosoted wooden poles, about 38 ft. long, erected A-wise, strutted or stayed as required, are used on straight runs, and moderately wind swept routes. Along exposed positions and over road crossings substantial H posts are substituted. Spacing is taken at 30 to 35 to the mile, but extra posts are inter-spaced when circumstances demand this in mountainous districts. Galvanised angle or channel section iron cross arms are fixed to the poles. To these, standard 35,000 volt porcelain insulators, partly of British and partly of

American make, are used to support the line conductors. The cross arms are all earthed by connecting them through a galvanised iron wire to a continuous earthwire, which is earthed, through a copper wire to a buried earthplate, at every fifth pole. The above type of transmission line serves the slate quarries, the Marconi Radio Station, the granite quarries at Penmaenmawr and the Dolgarrog power house. As the line connecting Dolgarrog and Colwyn Bay traverses the River Conway and a few gullies, lattice girder masts, fixed on concrete footings have been substituted for the wooden posts at these points. Various forms of lightning arresters are used including the water jet type and Moscicki condensers. A view of some of the lattice poles is given in Fig. 1 below.

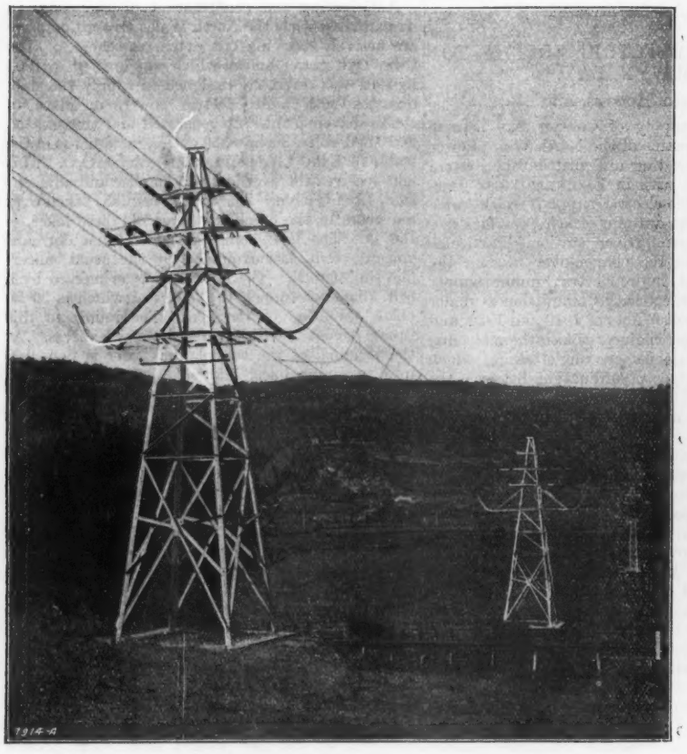


FIG. 1. LATTICE POLES ON 33,000 VOLT TRANSMISSION LINE.

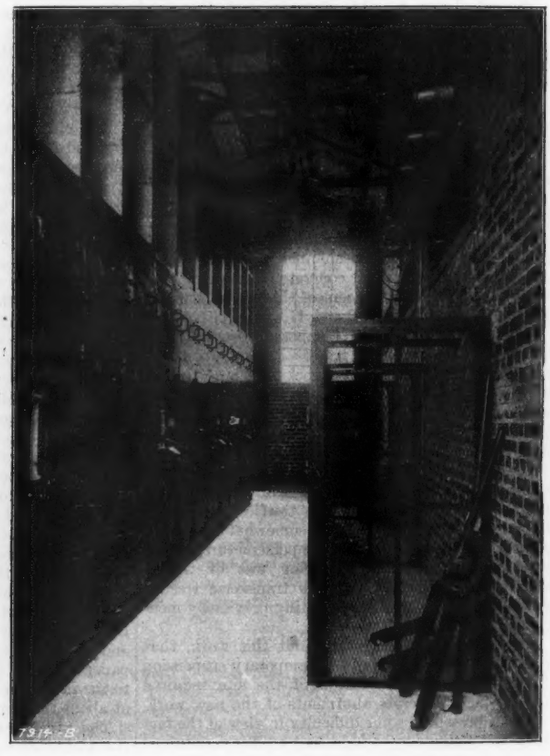


FIG. 2. INTERIOR VIEW OF STEP-DOWN TRANSFORMER SUBSTATION.

The Dolgarrog power station situate on the River Conway, to the east of, and about 22 miles from, Cwm Dyli, operates the extensive works of the Aluminium Corporation, Limited, in addition to the electricity supplies indicated above. The main source of the water for actuating the prime movers in this power house is at present formed by Llyn Eigiau, situate in a watershed adjoining that of Llyn Cowlyd and to the north of it. Surplus waters from the Dulyn and Melynllyn watersheds supplement Llyn Eigiau. From the lakes in this region the supply of potable water to Llandudno originates. The surplus waters from the Dulyn and Melynllyn lakes are conveyed through by a tunnel penetrating the mountain separating the two valleys. For about 2 miles, the water from Llyn Eigiau runs down the natural stream course and is then by means of a catchwater conveyed to a concentration reservoir, at 1,050 ft. above O.D. and immediately above the Aluminium Corporation's works. Means are taken to deliver compensation waters and to divert overflow waters in the district of the penstock chamber or forebay. From the forebay the water is conveyed through a 36-in. internal diameter steel pipe line to the power house in the Dolgarrog works which is 24 ft. above O.D. on the banks of the Conway river. Thus a head of about 1,020 ft. is available. The average rainfall in the Dolgarrog area is 83 in. per annum taken over a period of ten years. A description of the new dam and the arrangements made between the Joint Water Board and the Corporation, as to withdrawals of water by the latter was given in the article in ENGINEERING on June 15 last. The total capacity of the new lake is taken at 3,110 million gallons.

The plant, at present installed in the Dolgarrog power house for bulk supply of electricity, consists of two twin Pelton wheels similar to those at Cwm Dyli, controlled by oil pressure governors, coupled directly to 1,200 kw., 1,100 volt, 50 cycles, 3-phase alternators, supplied by Bruce Peebles and Co. The high tension switch arrangements here permit of the transmission lines from Cwm Dyli being directly connected to the transmission lines to the Colwyn Bay static transformer substation and for switching in the high tension current generated by the alternators at Dolgarrog as and when required.

The metallurgical processes of the Aluminium Corporation are operated by a plant of low pressure direct current generators, coupled to Pelton wheels, augmented by two 600 kv. motor generators for converting alternating current at 1,100 volts to direct current at 75 volts and 125 volts. The programme of further developments under the Order of the Electricity Commissioners embraces the harnessing of the water power at Maentwrog, in the Vale of Festiniog, to the south and west of Snowdon. Here the average rainfall is about 93 in. per annum. The first instalment of generating plant in this watershed will not be less than 12,000 kw. capacity. This station will be coupled by duplicate transmission lines to Cwm Dyli and as otherwise specified by the Commissioners. Thus the district under the order will be served by water power stations in triplicate. It would appear that as far as human foresight can mitigate failure in supply, the North Wales Power Company have well considered the public interests.

Turning now to the details of the Colwyn Bay supply we may first deal with the Bron-y-nant step-down transformer house. This is a two-storied brick building, erected at the extreme western boundary of the Colwyn Bay Urban District Council area and shown in Fig. 2 above. The top floor, of reinforced concrete, supported on double tee steel joists, is reserved for the 20,000 volt or 34,600 volt switch gear. The lower floor, of plain concrete is laid on prepared ground raised about 4 ft. above the main Conway-road, which passes alongside. This lower floor is divided longitudinally, into two compartments, by a brick wall. The front compartment, nearest the road contains the oil-immersed self-cooled transformers, supplied by Messrs. Ferranti, Limited, of Hollingwood, provision being made for three. Two of 1,000 k.v.a. capacity, 3 phase, with transforming ratios of 34,600/6,600, 20,000/6,600 are already installed. The 6,500 volt current now being delivered to the motor converter station in Ivy-street, is taken from tappings on the secondary coils.

The back compartment forms the 6,600 volt switchboard room. The transformer compartment is closed by three wooden sliding doors suspended in runners. These doors are so arranged that one padlock secures the three. The transformers can be wheeled from the deck of a lorry into position, without the help of hoisting tackle. As already stated two sets of lines connect the Dolgarrog power house and this transformer substation.

The incoming transmission lines are brought to six sets of terminal shackles, each formed of waved shed insulators, four bolted to one another in tandem. The arrangement is shown in Fig. 3 on page 73. The bare stranded copper line wires, each of 0·100 sq. in. section, are led into the building through Thomas's tubes, fixed, not less than 8 in. apart, in a cement panel. The latter is inserted in the wall of the building in a position about 8 ft. from the roof to the centre of the panel. Inside the upper room the line wires are solid and carried on white porcelain pillar insulators. Spacing is not less than 8 in. between any two bare conductors. Immediately the lines are clear of the walls, tappings are intended to be taken for connecting through choke coils and link switches, to the Moscicki condensers, not yet installed. Each phase line is then carried horizontally, some 15 ft. above floor level, to a choke coil, then into the top compartments of the sheet steel enclosed cubicles, in which are placed three single-pole, link isolating switches.

They are operated by hand by means of an insulated wooden staff, from floor level.

In separate compartments each phase-line is then carried downwards on pillar insulators, to automatic oil switches, fixed in the front part of the cubicles and through current transformers. The overload switches are rated at 150 amperes at 44,000 volts. Each phase line is then carried, upwards, to single-pole link switches and thence to its own bus bar of copper tube ¾ in. diameter. These bus bars are run longitudinally, the whole length of the top back part of the cubicles, thus making them available for dropping connections, through a 3-phase oil switch, to another set of 34,600 volt bus bars, running parallel to, but situate at nearly floor level, below the upper bus bars. Transversely, the bus bars are staggered one to the other, so that ample air insulation is provided between them both horizontally and vertically. From the lower bus bars, circuits are dropped on pillar insulators, through the top floor, to link isolating, selecter, switches, immediately over each step-down transformer. All E.H.T. circuits are operated on the top floor. The fixed sheet steel cubicles have 12 compartments, and these with switch gear were supplied and erected by Messrs. Ferguson Pailin, Limited, of Manchester. Six sets of cubicles control the incoming 3-phase lines, so that either line or both can be connected to the E.H.T. bus bars. A set of three is held in reserve for a 34,600 volt transmission line to link through to the Conway substation. Thus an alternative supply from Dolgarrog via Conway will be available. An interior view of the substation is given in Fig. 2 on page 72.

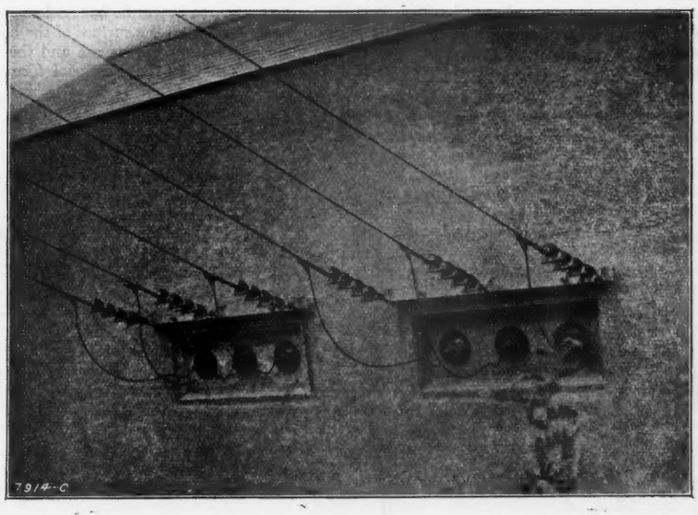


FIG. 3. 33,000-VOLT INCOMING LINES TO SUBSTATION.

The transformers are at present coupled up delta-wise to suit the supply from the hydro-electric station at 20,000 volts. When the supply at 34,600 volts is substituted, the coupling will be star-wise. The 6,600 volt, 3-phase circuits from the secondary windings of the transformers are carried on pillar insulators and Thomas's tubes through the walls to the bus bars at the back of the fixed portion of the switchboard, which, with the exception of gangways, in front and at one end, run the whole length of the building. It is intended to connect the neutral points of the 6,600 volt windings on each transformer through a non-automatic switch to an earthing resistance, for limiting the fault currents to earth. Each panel of the switch board, which is shown in Fig. 4 on Plate VIII, is a separate sheet steel cubicle, mounted on runners, so that this entity, with its contained switches, &c., when removed forwards, withdraws plug contacts from each phase bus bar and, at the same time raising a lever closes the port holes covering the sunk end connections on the live bus bars.

Three of the panels are allocated to the transformers and the switch gear is designed so that the secondary of either transformer can be connected to the 6,600 volt bus bar. Four of the remaining panels control the feeders to the distributing stations. The end compartment seen in Fig. 4 is allocated to a 30 k.v.a. 3-phase, 4-wire transformer (ratios of transformation 6,600/400 volts and 230 volts) with accessory switches and protective fuses for the supply of electricity to an area immediately surrounding the substation and for power in the adjacent gas works. This local supply is metered through a 3-phase, 4-wire, unbalanced load integrating wattmeter.

Two feeder panels control the input to the two 3-core, armoured, feeder cables, connecting the substation and the motor converter station, about 1½ miles distant. The two feeders, 0·100 in. sectional area, 3-core, paper insulated, lead covered, and steel tape armoured cables, laid at a minimum depth of 2 ft. directly in the ground, partly through intervening fields and partly along the roads or footpaths. They were supplied and laid by Messrs. Glover.

The Ivy-street motor converter and distributing station situated in Colwyn Bay, almost in the centre of the area of supply is built of brick with Ruabon facings to plinths, &c. Steel roof principals are used with timber purlins and a slate roof. The building is designed to accommodate four motor converters of 500 k.v. output each, making a total of 2,000 kw. compared with the 540 kw. capacity of the discarded steam driven plant. A 10 ton overhead, hand operated, travelling crane serves the inside of the building. The contractor was Mr. T. B. Gorst, Colwyn Bay. The motor converting plant was supplied by Messrs. Bruce Peebles and Co., of Edinburgh. The machines installed at present comprise two sets each of 125 kw. output, one set of 300 kw. and one of 500 kw. They all run at 750 r.p.m. The 125 kw. sets are each connected to a step-down, oil-immersed transformer, cooled by radiating fins and made by the Foster Engineering Company, Limited, Wimbledon. The ratio of transformation is 6,600/2,950 volts and the output 150 k.v.a. at 50 cycles. The direct current in each machine is generated at from 440 to 550 volts, the machines being shunt wound with interpoles for lighting at 440 volts and compound wound for traction at 550 volts. At view of the interior of the station is given in Fig. 5 on Plate VIII.

The 6,600 volt switchgear is of the armour-clad, draw-out type and was supplied by Messrs. Reyrolle and Co., Limited, Hebburn-on-Tyne. The gear is made in two parts, interconnected by a bus bar section. There are two feeder panels with interconnecting switches between the four machine panels, two of which are placed on each side of the feeder panels. The board is shown in Fig. 6 on Plate VIII. Each feeder unit is provided with an overload relay on each phase circuit, and with appropriate measuring instruments.

The low tension direct current switchboard, which is shown in Fig. 7 on Plate VIII, contains 10 slate panels allocated as follows:—

4 generator panels shown to the right side of Fig. 7 and 1 spare for extension.

1 summation and 4 feeder panels for 8 district feeders, with their complement of recording and indicating measuring instruments. The regulating resistances of the direct current generator shunt coils are fixed over the gangway at the back of the board, the operating hand wheel being placed in the centre of each panel. The summation panel shown to the left of the spare panel in Fig. 7, is provided with an indicating ammeter in each circuit to the bus bar of the 3-wire distributing system. One ammeter to indicate the balance or otherwise of the system and an earth-leakage ammeter, two recording voltmeters, one recording ammeter for registering the balance of the system and two watt-hour meters for recording the output. At the foot of this panel the earth switch is mounted. The feeder panels are equipped with circuit breakers and ammeters.

The central area of the urban district is served for the present with direct current through a 3-wire distributing system at 440 volts between the outers. The extensions of the distributing area in the western districts are, however, supplied with alternating current, through step-down transformers. Should the application, now being made to the Electricity Commissioners to authorise supply with alternating current only be granted, the conversion of the present direct-current supply will be effected as conveniently as possible. The present charge for electricity is 8*d.* per unit, and until the demand has doubled the present output it is hardly likely that this figure can be much reduced. The district is mainly residential although a small power load is furnished by laundries, a shoe factory, boot-repairers' machines, an ice-making factory, mincing machines, grocery and bakery accessories and agricultural machinery. The supply to the local tramway company has not yet been arranged.

The output of the local electricity undertaking in 1901, the first year of public supply, was 65,233 units. For the year 1921–1922 the output was 669,967 units.

Thanks are due to Mr. G. K. Paton, M.I.E.E., the Consulting Engineer, and to Mr. J. Smith, the Resident Engineer, for information and some of the illustrations on which this article is based.

THE INTERNATIONAL NAVIGATION CONGRESS.

(*Concluded from page* 46.)

THE UNIFICATION OF INLAND NAVIGATION STATISTICS.

THE last "communication" to be dealt with by the Inland Navigation Section was concerned with the question of the "Unification of Statistics of Inland Navigation with a View to Facilitating the Comparison of the Results of the Working of Navigable Waterways in Various Countries." This communication was discussed on the afternoon of Thursday, July 5. The general reporter on the question was Mr. H. Eneborg, editor of the *Royal Administrative Journal of Commerce of Stockholm*, and reports were presented from the United States, France, Italy, the Netherlands, Sweden and Czecho-Slovakia. This matter is hardly of the direct engineering interest of the majority of the others which were considered by the Congress, and it is not necessary that we should deal with it in any considerable detail. We accordingly propose to confine ourselves to a summary of the general report, making any reference to the detail papers merely incidental.

This question of the unification of inland navigation statistics has been before the Congress more than once, but it cannot yet be said that its deliberations and recommendations have had much practical effect. Mr. Eneborg pointed out that the matter was dealt with at the meeting in Frankfurt in 1888, and at the Manchester meeting of 1890, and attributed the practical failure of the recommendations to the fact that they had been too extensive. The authorities which would have been required to furnish statistics had been asked to undertake more

work than they could reasonably manage, and the result was that little or no action had been taken in any country. Mr. Eneborg was of opinion that the only effective way to obtain a real basis for uniform statistical returns from all countries, was to address a detailed questionnaire to the Governments of all such countries, and he suggested that the Congress should appoint a committee to draw up such a questionnaire. It was very important, however, that the mistake of the past should not be repeated, and that not more information than might reasonably be expected to be available should be asked for. It had to be borne in mind that conformity in international statistics had hardly been obtained in any sphere and certainly not in the economic field.

Dr. G. G. Huebner, Professor of Transportation and Commerce in the University of Pennsylvania, who compiled one of the detail papers, suggested that international inland navigation statistics should include accurate data of reasonable details concerning (1) the condition of navigable waterways, (2) inland vessels, (3) traffic, (4) capital, earnings and expenses, and (5) accidents; while Dr. Archinto Berni, secretary of the Chamber of Commerce of Mantova, Italy, thought the statistics should cover (1) data on navigable waterways, (2) boats, (3) traffic, and (4) accidents. Mr. Eneborg was, however, of opinion that both of these programmes were much too extensive and were as little likely to lead to tangible results as previous recommendations. The same point of view was made evident in the paper by Dr. Vaclav Partl, Conseiller à la Section de Navigation du Ministère du Commerce, Prague, who said that, especially to begin with, inland statistics should be limited to figures which were really of international interest.

Mr. Eneborg thought the probability of attaining greater uniformity and completeness in the statistical data relating to the inland navigation of different countries was somewhat greater at the present time than in 1890, when the International Navigation Congress recommended a standard code. He based this idea to some extent on the detail reports received and on the growing importance of the subject in the last ten years. The Government expenditure of various States on internal waterways had also increased considerably, which made the matter of growing direct Government interest. Ultimately full freedom for a country to participate not only in coastal navigation, but also in traffic on inland waterways of other countries would probably develop so that uniformity of statistics for such inland traffic would become an absolute necessity.

Such uniform statistics might well be limited to such waterways as were either connected with the sea or with other countries. Purely inland and self-contained waterways were of little interest to outsiders. Even for the waterways the traffic on which was of international interest, however, some limit of size might be fixed, and the traffic on very narrow or shallow waterways navigable only by very small vessels might well be excluded. Again it would probably be necessary to limit the statistics to vessels above a certain size. The minimum size of vessel might, however, be different on different waterways or in different countries to suit local conditions. By limiting the collection of data in this way accurate figures were more likely to be obtained, since the employees on the larger waterways and on the larger boats would be more qualified to fill up the necessary forms than the men concerned with the smaller classes of traffic. The international statistics should cover only figures relating to traffic. The figures would deal mainly with arriving and departing vessels, but in some countries figures would also be required for timber rafts and loose timber which was transported by water on an extensive scale. It would probably be desirable that traffic of this kind should be shown separately.

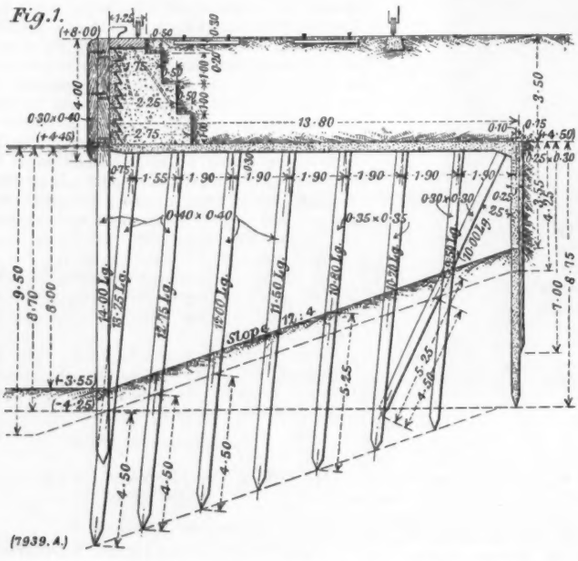
The main statistics should comprise a statement of the number and tonnage and vessels which had passed on a waterway and corresponding data for vessels arriving at or departing from harbours on inland channels. Information about the ports arrived from or departed for should also be given. The type of vessel and size should also be specified. This last item raised the question of a uniform method of ship measurement. At present there was great variation between the practice of different countries, and the question had recently been considered by the Section of Communication and Transit of the League of Nations. The best measures of the activity of navigation from the goods transport point of view were the deadweight tonnage and the weight and volume of the cargo, but such figures were included in the returns of very few countries. The manner of specifying various commodities varied greatly in different countries and did not agree with the nomenclature and groupings used in foreign trade or railway traffic statistics, and it would be necessary for the proposed statistics and generally of great value that some international uniformity in nomenclature could be introduced. Mr. Eneborg finally proposed that a report should be prepared on this whole question by a special committee appointed by the Permanent Association, and should be presented to the next Congress.

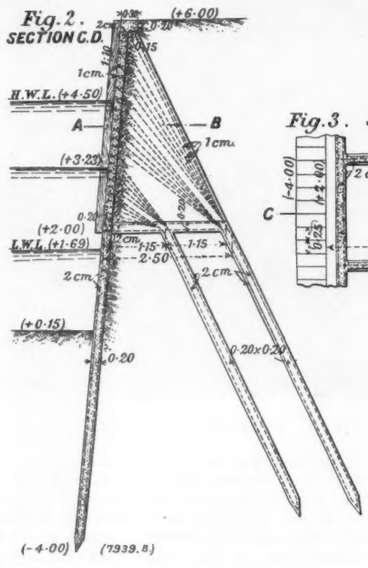
Hydraulics Laboratory of the Technical High School at Brünn.

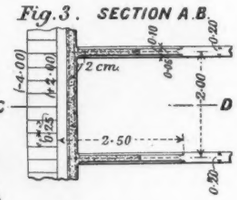
The last meeting of the inland-navigation section took the form of a kinematograph lecture by Professor A. Smrcek dealing with the hydraulics laboratory of the Technical High School at Brünn, Czecho-Slovakia. Professor Smrcek illustrated and described the equipment of the laboratory, but the greater part of the lecture was devoted to an extremely interesting series of model experiments on weirs, the experiments being arranged mainly for the investigation of the erosion effects on the river bed of weirs of different designs.

The experiments were made in a channel 1 m. wide, and 1·05 m. deep, the length of the working portion being 15·1 m. The bed of the channel was formed of coarse sand or fine gravel, upon which the model weir was mounted, and the sides of the channel in the neighbourhood of the weir were formed of plate glass. It was thus possible to watch and to photograph, not only the nature of the flow at various heads, but also the effects on the bed. The latter, Professor Smrcek stated, had been found to be in good agreement with those obtained in full-scale work. The effects were illustrated by kinematograph pictures for the case of a special form of adjustable weir used on the Elbe, for ordinary inclined and vertical masonry weirs and for weirs of sinusoidal form. Although particularly interesting and instructive to watch, the effects are difficult to describe in words, but noticeable features were the movement of the surface of the bed against the main direction of the stream and the retention of floating bodies in the whirlpool formed immediately below the weir in some cases. Another interesting feature demonstrated was the undermining and destruction of vertical weirs by flood flow; one of the weirs of this type shown, tilted over and became buried in the bed of the channel. The protection of the bed by concrete floors of different shapes was clearly shown, one of the best forms being that in which the floor rose gradually from the down-stream face of the weir in the form of a flat curve terminating in a horizontal surface.

There was no discussion on the lecture, but in thanking Professor Smrcek at the conclusion of the film, the chairman expressed the hope that arrangements would be made for showing it to a larger audience—a suggestion which we hope will be given effect to.







Concrete and Reinforced Concrete.

The first "Communication" considered by the second section of the Congress was taken on Thursday, the 5th inst. The official wording of the title was "Concrete and Reinforced Concrete. Their Applications to Hydraulic Works; Means to Insure their Preservation and their Watertightness." Fourteen reports were sent in from eight countries. The general reporter was Mr. G. W. Humphreys, who, after summarising the individual reports recorded that it was evident that concrete and reinforced concrete work had become accepted practice. Not so much had been done in France as elsewhere, owing to the excellence and cheapness of French masonry. The work was now being more

largely adopted in that country. On the subject of so-called adulterants, Mr. Humphreys appeared to support the theory that the addition of puzzolanic compounds had some definite value, and research in this direction was necessary. Structures of concrete often offered the most economical solution of problems. Design for marine works should be specially studied and minimum thicknesses and cover of reinforcement adopted. Further research into the chemistry of setting was desirable.

The Belgium report was drawn up by MM. R. Derycke, P. Goossens and J. Haché. This report described a number of recent marine works, some completed since the war and others constructed during the German occupation when materials were scarce. These changes affecting the supply of materials had resulted in some of the larger works being composite in character. A feature of recently constructed quay walls appears to be the adoption of a form of construction consisting of a concrete platform supported on concrete piles, and carrying at its outboard edge a brick or concrete wall protected by timber sheathing, earth filling to the depth sometimes of 11 ft. being placed on the concrete platform to bring the level up to that of the quay coping. At the shore edge of the platform a line of concrete sheet piling is driven and made watertight. A typical example, one of several illustrated in the report, is shown in Fig. 1 on the opposite page. This illustrates the design of walls on the Ghent Canal, at Ghent and at Ternenzen. In some cases the sheet piling has been made watertight by using piles grooved on both edges and driving between them wooden tongue strips or grouting up with cement.

Another interesting design of wall described in the report was a reinforced concrete quay wall adopted for Termonde. This is shown in Figs. 2 and 3. In this case a line of concrete sheet piling is driven along the front of the wall to a batter of 1 in 10. This is finished off by a longitudinal capping below low-water mark. Above this a reinforced wall is raised gradually tapering to quay level, where it is finished with an inset coping. At the back of the wall at intervals of 2 m., centre to centre, counterforts are placed resting on beams which run from the wall in front on to the heads of two rows of piles, driven to a considerable batter. Reinforcing bars run from various heights in the front wall and converge in two groups to the pile heads. The wall is of light construction. Welding instead of binding is adopted for all bars in the piles. For these works slow setting basic slag cement was adopted with an addition of granulated slag, as it enables a good bond to be secured in spite of the intermittent nature of the operations. Ciment Fondu was considered, but a very slow-hardening cement had the advantage that one portion has hardly set before work is recommenced on the next tide. The report further described an expedient adopted on a confined site for the construction of piles and slabs. A smooth floor of rammed sand was laid down and side boards raised on it to form the moulding boxes. These were spaced very carefully, and when one set of piles were run, the boards were removed and the finished piles coated with clay wash. The spaces between these piles were then used for another set, the sides of the finished piles forming the moulds. When one layer had been completed on ground level another was moulded in the same way over them, and so on to the extent of four layers.

The Danish report was in two sections respectively by M. A. Poulsen and M. J. Munch-Petersen. The former's portion dealt with characteristics of cement and concrete, the latter's with examples of recent work. M. Poulsen contributed a lot of data derived from official tests carried out in Denmark on the action of sea water on cement and concrete. In all these tests cements of various qualities had failed after exposure for a varying number of years to salt water and frost. The cement was partly decomposed by the salts, and frost and water had a serious effect on the parts affected. The richer mixtures stood best. Experiments on large blocks confirmed these results. M. Poulsen next dealt with the value of puzzolanic materials, contending that the addition of Rhenish trass or a Danish diotomaceous earth known as Mo-Ler had beneficial effects in connection with sea structures, as they provided soluble silicious acid, the result being extraordinary resistance to chemical influences and a higher strength than that of simple Portland cement mortar. The works described by M. Munch-Peterson include piers formed of reinforced concrete caissons anchored to the bottom and filled, and others built of wooden forms filled with aggregate and grouted.

M. Voisin presenting the French report, explained that owing to the excellence of French masonry, concrete was formerly not adopted for marine works. With the higher price of labour it had become advantageous, but its use required very great care. A number of works were described involving the use of concrete in different forms and of various qualities. The results given in several instances showed that early works in some cases had not proved altogether satisfactory. They have shown cracks, with rusting of reinforcement, and flaking. On the other hand, many works had remained perfectly good. M. Voisin recommended rich cement facings and a minimum cover for reinforcement of 3 cm. to 5 cm. Coal tar was a good protective and marine molusca also protected surfaces. The parts which suffered most were those uncovered by the tide, or just above water level where there were no tides. The use of slag cements and of puzzolana, as well as Ciment Fondu, was referred to, but these materials had only recently been tried and sufficient time had not elapsed to give experience with them.

Of the five reports submitted by representatives of Great Britain, that of Mr. S. D. Carothers was devoted entirely to a consideration of the change of volume, porosity and permeability of concrete. Mr. Carothers referred to experiments on porosity made at Chatham for the Admiralty, which showed that there was a certain percentage of voids in all mixtures when wet, but this could be reduced to small proportions. It was important not to use more water than was required for hydration, as the evaporation of the extra water caused porosity. This void space was probably augmented in course of time by crystallisation with contraction of volume of the essential cementing material.

The report by Mr. James Mitchell was favourable to the use of concrete for marine structures, provided it was properly made. Reinforcement had opened a new field for it. Mr. Mitchell advocated a rich mixture instead of surface protection, though tar was useful. With good grading and careful handling very satisfactory work could be done. The danger of wet mixtures was that the grouting often ran away in pouring, leaving a poor mixture of coarse aggregate behind, or the larger material tended to settle, the liquid rising to the top. The latter should be cleared off. Excess water was expelled during setting.

Mr. W. Cleaver presented some remarks on the protection of concrete work by adequate timber fendering, and recommended spring fendering composed of timber piles, with capping, &c., set away several inches from the main concrete structure, coiled springs being inserted between the two. Mr. Mitchell Moncrieff contributed a review of the subject of the deterioration of concrete from 1886 onwards, giving his experience in two interesting cases, which had come under his observation, of the deterioration of dock structures owing to the expansion of the concrete as a result of its high permeability. In one case a dock wall had increased in height in course of time, as it deteriorated, by no less than $7\frac{3}{8}$ in.

The remaining British report was by Sir Robert Hadfield and referred to the liability to corrosion of ferrous metals in sea water. This report described the work of the committee of the Institution of Civil Engineers and the experiments they were carrying out with specimens of wrought iron, steel and cast-iron in various ports all over the world. The copper-steel alloys were also discussed as well as "Armco" iron and rustless steels.

The Japanese report by Dr. K. Aki and Mr. S. Okake confined itself to the type of construction adopted for extensions at the port of Yokohama for quay walls. These walls are being built of reinforced concrete caissons, each of which consists of 14 vertical cells arranged in two rows of 7. The interior partitions are flat walls, but the exterior of each cell is a segment of a circle and the caisson sides, therefore, consist of a series of horizontal arches. The exterior at water level is finished flat, up to quay level, and fitted with timber fendering. The back row of cells are filled with sand, the front with concrete, a central shaft being left in each. The reinforced caisson as placed in position and before filling is a relatively light piece of work.

The report from Holland by MM. J. A. Ringers and C. Tellegen is noticeable for the reference it makes to experience on works described at previous congresses of 1908 and 1912. This experience would seem to have been only partly satisfactory as some types of construction adopted at those dates have proved unsuitable, and have been abandoned. Failure would appear to have resulted in most instances from mechanical causes such as erosion at the toe of revetments by storms, unequal settlement, &c. In such cases the strength of the construction has been overtaxed and collapse has followed. In several cases failure of the concrete or cement itself is noted, due it is held to permeability and the failure to harden in air before placing in salt water; this obviously applies only to blocks and pre-cast work since work cast *in situ* is often flooded by the next tide. The report subsequently described the type of caisson construction adopted for quay walls at Rotterdam. These are large interlocking cellular blocks, the front cells being filled with concrete and the back with sand. Latterly reliance has been placed on the strength of the reinforced concrete partitions and concrete filling of part of the caisson has been abandoned, and the whole filled with sand. The type of quay construction now adopted at Amsterdam is on similar lines to that described and illustrated in Fig. 1, on page 74, in connection with the Belgian report. In Holland, however, timber piling has been retained in waters in which borers are not present, reinforced concrete being adopted in waters infected by this pest. The addition of trass was found to improve the impermeability of concrete as shown in tests extending from 1912 to 1922. Further trials were being conducted in Holland. Rich mixtures tended to resist deterioration in sea water, and with such mixtures reinforcement could be placed as close as 2 cm. to the surface. Watertightness, however, was better attained by careful grading of sand and aggregate than by the addition of too much cement, owing to questions of contraction. Wet concrete was preferable to dry rammed concrete, and maturing in damp air was to be recommended.

Two reports were submitted from Spain, one contributed jointly by three authors dealt with recent works on the rivers and coasts of that country. This was by MM. Maese, Becerra and Delgado-Brackenbury. It described in some detail the methods adopted at the port of Valencia, at Musel, near Gijon, and at Seville. It was stated that concrete work for sea water required extreme care in execution, that the work should be arranged so that the concrete could be properly matured before being immersed in sea water. The construction of moles by means of caissons was described, and the operation of floating to site and of placing in position discussed. At Seville the water was fresh and works became coated with a protective slime. The second Spanish report was a little difficult to follow. It was by M. Ed. de Castro and was concerned wholly with the deterioration of concrete in sea water. As far as can be gathered the author aimed at showing that deterioration was due to the presence of lime, and that if this material could be washed out of concrete a porous but permanent material would remain. There were, however, in use at the present time in Spanish ports cements which on account of their lime content would not comply with any usual specification. These were often quite successful in marine works, and he considered the reason to be that they contained puzzolanic substances derived from marl, which formed stable combinations with the lime. Impermeability in itself was not an essential quality, but it was advantageous as it delayed the penetration of sea water and gave more time for the lime in ordinary concrete to change to stable combinations. Impermeability could be attained either with a rich mixture or by means of good proportioning; an excess of water was essential.

The last report on this subject was one for Sweden by Mr. K. Petterson. This indicated that confidence

was felt in the use of concrete and reinforced concrete for marine works, in many instances in combination with timber piling in waters free from borers. Old work had stood and new extensions in the same materials had recently been completed or were in hand. At Göthenburg interesting repairs were carried out to a quay formed of a concrete deck carried on piles. In course of time this had settled considerably and the old deck had been built over with a hollow, concrete structure above which filling was introduced to bring the whole up to quay level, the front wall being raised at the same time. For a new quay at the Central harbour a concrete deck was adopted built on timber piles, tongued and grooved reinforced concrete sheet piling being driven along the outer line of the quay and bonded to the deck. A reinforced, stone-faced quay wall was built on the deck. The deck was built in sections in the dry, beneath water level by means of a large rectangular bell carried by travelling gantry frames. The track for these frames was laid on rows of temporary piling, and the bell, measuring 10 m. by 7·5 m. by 5·1 m. in height, was raised and lowered by means of screws. Other forms of construction described in the report related to the use of caissons, particulars being given of light reinforced concrete caissons employed at Hälsingborg. At Uddevalla, where timber was attacked by borers, protection has been given to piles by surrounding them with a concrete casing in which wire netting was introduced as reinforcement. This casing was applied before driving, the timber interior being surrounded first with thick paper. Such piles had shown no sign of deterioration in twenty years.

The discussion on this report was very brief, M. Voisin suggesting certain slight modifications in the conclusions. In particular he thought that the use of ciment fondu and of the cement gun might be definitely specified.

Liquid Fuel.

On the second communication considered by the second section of the Congress there were eight reports, submitted on behalf of seven countries; the official wording adopted for the topic was "Use of Liquid Fuel for Navigation and its Consequences." These reports nearly all covered similar and well-known ground with slight variations and extensions. The general reporter was Sir John Cadman. Generally speaking the advantages of liquid fuel were considered to be greater cleanliness; greater range for equal capacity on board, or equal range for less bunker capacity; greater convenience in stowage; greater ease in shipping; smaller boiler-room staff; improved conditions in boiler room (cleaner, and lower temperatures); better regulation of output and wider range in a short time; improved bulkhead arrangements possible, &c. The use of oil fuel was considered essential in naval vessels for which it presented great advantages over coal. In this connection its use under boilers was likely to persist. In many high-powered liners it was likely to be used to a considerable degree in the future in the same way. Other passenger vessels were likely to use oil or coal, whichever presented the advantage in price for the time being. Cargo vessels had to adopt the fuel available at ports to which they might trade; at most of the larger ports new supplies of oil fuel were procurable. For the latter class of vessel, however, the future seemed to be with the motor-driven ship owing to the economy of fuel, which more than offset the higher first cost and shorter life of the internal-combustion engine. The internal-combustion engine ship had the disadvantage that it was not convertible to coal, while the carriage of oil in bunkers and tanks necessitated better workmanship than is commonly put into such parts.

The position as regards the future, Sir John Cadman summed up as reassuring. Present known supplies indicated that there would be sufficient to last possibly 100 years, while large tracts still awaited exploration. By the end of the time stated efficient substitutes would be forthcoming from coal distillation and other sources, and fuel economy would have made great advances.

The report for Chile by M. Max. Prado was a review of the whole situation in which the general argument was in favour of liquid fuel. The report for the United States, drawn up by Mr. U. T. Holmes, was one of the most comprehensive in some respects, but statistics, &c., were carried down only till 1913. Mr. Holmes considered that coal had about reached a constant yearly output. The production of crude oil had also reached a substantially steady figure and the price would be based on that of coal and would vary automatically with it. Plain crude oil, though much used, was not altogether desirable and the lighter vapours should be distilled off. MM. R. Boris and G. Bricard for France considered that in order to conserve fuel supplies the burning of oil under boilers should be abandoned in favour of the internal-combustion engine. The combined boiler system of burning coal and simultaneously using oil fuel when maximum power was needed had been tried, but abandoned in the French Navy, owing to the difficulty in arranging for the different proportions of air needed for coal and oil.

Engineer-Captain A. E. Hyne, R.N., for Great Britain, summarised the advantages of liquid fuel under 14 heads, including the points named above. The internal-combustion engine was not yet suited to high-powered vessels, and coal could not be reverted to as when using oil under boilers. With oil there was less actual danger from fire than with coal. Mr. J. J. Kermode, also representing this country, gave comparisons for a fast channel steamer using coal and oil, from which we quote the following:—

	Using Coal.	Using Oil.
Number of trips in 72 hours	10	12
Time required to bunker ...	15 tons per hour	80 tons per hour
Fire-room *personnel* ...	14	4
Average speed	18¾ knots	20 knots
Fastest speed	20¼ knots	21¾ knots

The proper use of fuel oil required special ship design, and special boiler design, with possibly modification of engine design.

The report for Italy was by M. C. Baulino, who referred specifically to the use of oil fuel in Italian warships. He considered that everything should be done to develop the internal-combustion engine with a view to conserving supplies. A Roumanian report by M. G. Popesco stated that fuel oil was used in passenger boats of the Roumanian State Service, but that in cargo boats oil fuel presented no advantage over coal on a round voyage. The question of price generally made it advantageous for Roumanian services, but future developments would be restricted according to the stocks held at ports abroad.

M. Gustaf Seth reporting for Sweden pointed out that that country had neither coal nor oil supplies, and that of the two imported fuels oil presented considerable advantages over coal. Oil was used under boilers, but not to the extent that its use in internal-combustion engines was being developed.

In the discussion which followed the reading of Sir John Cadman's report MM. Bricard and Boris, the authors of one of the papers, called attention to certain observations made with tug boats on the Seine where the steam tugs were found to take ten times as much fuel as the oil tugs. Thus stated, however, the figures were rather unduly favourable to oil as the steam tugs took a train of nine barges whilst the oil tugs took six, so that a fairer comparison would be that for equal work done, the oil tugs took about one-seventh the weight of fuel required by the steam barges. The work was of a somewhat special character. No towing was done at night, during which the fires of the steamers were banked down, and moreover, fires had also to be banked in passing through locks, whilst under corresponding conditions, the oil tug used no fuel whatever. Their manoeuvring power was found to be quite satisfactory, but if oil tugs were to be used for work in docks it would be advisable to increase somewhat the store of compressed air. As for storage, ferro-concrete tanks had been successfully used in America, one at Chicago being 110 ft. in diameter by 30 ft. deep.

Utilisation of Tidal Power.

The last communication considered by the Ocean Navigation Section of the Congress was concerned with the utilisation of tidal power, but the terms of the reference were somewhat limited, the wording actually being "Utilisation of Tides for the Production of Power for the Working and Lighting of Ports and for Maritime Works (Working of Lock Gates, &c.)." This limitation proved somewhat of a stumbling block to the individual reporters, and the general reporter, the late Mr. C. S. Meik, in an excellent little summary of the several contributions, and general survey of the subject, pointed out that most of the communications were rather beside the point. The fact is that many wandered off into general dissertations on the causes of the tides and broad figuring on hypothetical bases. Most of the authors preferred to consider the development of power by the tides as a general proposition, without connection with the operation of works required by shipping.

Mr. Meik remarked that several argued on lines which suggested that choice in the matter of site for the power plant was possible, whereas the communication was intended to deal with the feasibility of developing power at ports at which in most cases cheap power was already available. Although the maximum head was often considerable the average head was usually low, and the times during which it was available added complications. If the water used had also to be employed for locking vessels, further complications arose. Storage increased the cost. No reporters touched seriously on this matter of cost, and in Mr. Meik's opinion it would be cheaper in nine cases out of ten to buy current than to instal tide-operated plant to supply it.

The report of M. Cattaneo for Italy indulged largely in historical matter and referred to schemes for combined tide and wave-power stations embodying inventions of the author with which he had been experimenting since 1917. From the report it is a little difficult to gather what the practical results of this work have been, and as Mr. Meik summed it up the report had very little bearing on the actual subject of the communication. M. Yanquez, contributing as the representative of Chile, confined himself to broad lines of estimates, frankly leaving the practical solution to others. The suggestions did not carry matters any further. M. A. de Rouville gave some details of the arguments which led to the suggestion to instal experimental plant on the coasts of Brittany, but these are primarily simple power plants, and not plants directly intended for the operation of marine works at ports. The specific application of such plants to ports was only considered in a general way.

It will probably be admitted that the two most interesting communications on this subject were by Mr. E. Latham (Great Britain) and M. W. J. Harmsen (Holland). The greater part, however, of Mr. Latham's communication was of a quite general nature, and after discussing the size of various schemes for a moderate output, he pointed out that navigation interests were of vital importance and the development of power from the tide of very secondary interest. The advantage of free tidal water he believed to outweigh any possible benefits from restricting the flow with the object of developing power. The report by Mr. Harmsen described a project in Holland in which the tidal flow is to be used at Hansweert, on the Zuid-Beveland Canal. The available head is said to be about 14 ft. and the appliance to be used is known as the "hydropulsor." It is admitted to be costly to construct and install, and also to maintain as it is subject to constant shocks. It is used to pump water into a high-level basin during the fall of the tide, and apparently this stored water is to be used for hydro-electric purposes when required.

Coast Lighting.

The last "communication" brought before the Ocean Navigation Section was entitled "Principal Advances made Recently in Lighting, Beaconing and Signalling of Coasts. Standardisation (Unification) of the Languages of Maritime Signals." The general reporter on this question was Mr. D. W. Hood, engineer-in-chief to the Corporation of Trinity House, while 14 detail reports were presented on the subjects of which Great Britian contributed five and Belgium, France, Holland, Italy, Japan, Russia, Spain, Sweden and the United States one each. Many of these reports contained information of much interest. Mr. Hood, in his summary of the various reports said that as regards the luminary for optical apparatus, authorities were

generally agreed that for buoy and beacon lighting, and in many instances for secondary lights, acetylene gas, either in an open burner or with an incandescent mantle, was the most popular form of illuminant where electricity was unobtainable. That dissolved acetylene gas, however, should be invariably used was open to question, as where a long luminous period was required or where the light was watched or semi-watched, the study of economy pointed to the fact that automatic generation of gas *in situ* should be fully considered.

For larger optics an incandescent mantle on a petroleum vapour burner was the most suitable illuminant unless electricity could be readily obtained at reasonable cost, when the incandescent electric filament lamp might advantageously be employed. The need for continued development in the illumination of lighthouses had not in the least diminished, and in no circumstances should it be neglected in the endeavour to develop Hertzian or acoustic fog warnings. The greater its power the more penetrative would be the beam from a lighthouse, and the greatest security was afforded to the mariner by providing a signal which he could see and recognise with his eyes. Little was said in the various reports about the combination of aerial and maritime lights, and Mr. Hood was of opinion that such a study was worthy of the Conference, in order to avoid separate aerial and maritime lighthouses on the coast.

In connection with acoustical fog signals, authorities generally recognised the superiority of the siren or diaphone over other types. Position-finding by wireless was destined to be one of the most important navigational aids of the future, whether employed alone or in conjunction with sound to obtain synchronous signals. Various countries had different direction-finding systems of their own, but the problem of the most effective type should be investigated not by each country individually, but by common international agreement. In Mr. Hood's opinion a system applicable to stations both ashore and afloat which employed a wireless beam, the direction of which was ascertained by the navigator himself, should be the primary basis for such investigation and development. The matter of the standardisation of sea marks Mr. Hood passed without comment other than the remark that the authors of several of the reports were of opinion that the ideal had not yet been reached. In connection with this matter, Mr. Hood added, as appendices to his report, copies of the resolutions on the colouring, numbering and lighting of buoys which were adopted by the Washington Conference of 1889, and the St. Petersburg Conference of 1912. It is not necessary that we should reproduce these, but we may quote from them in connection with any reference to them in the general discussion.

Turning to the various reports, the first in order of numbering was that from Belgium, written by M. F. Urbain, Hydrographe principal des Ponts et Chaussées, Antwerp. This dealt only with the question of the international standardisation of buoyage which, we do not propose to treat in any detail. M. Urbain's main point was that differences existed in many countries over what was to be understood by port and starboard hand sea marks, and he proposed that further efforts towards standardisation should be made. Matters of more direct engineering interest were dealt with in the Spanish report, which was contributed by Mr. Mauro Serret y Mirete, Adjoint au Service Central des Signaux Maritimes, Madrid. The report reviewed the progressive use in Spain of wick burners, gasolene and finally acetylene in lights of small orders and petroleum vapour and electric incandescent lamps in those of larger order. At the present time experimental work is being done with semi-Diesel heavy oil engines coupled to dynamos in hope of making the generation of electricity at a lighthouse more economical with a view to its extended adoption. Spain had two electric arc lighthouses, one at Cap Villano (La Corũna) and the other at San Sebastian (Cadiz on the Atlantic). The type of optical apparatus was then described. None of this was made in Spain, that in use coming principally from France; English, German and Swedish apparatus then following in the order given.

There were but few sound fog signals in Spain, there being two syrens for foggy weather, one at Finisterre and the other at Lisargas. There was also an explosive signal at Galea Point near Bilbao. The cartridge by which the signal was given was detonated by an electrical current. In 1913 it was decided to install three fog signals on the Straits of Gibraltar, but owing to the war the contract for these which had been placed in England could not be completed. One of the proposed syrens only has been supplied and has been installed at Ceuta. It is operated by two 9-h.p. oil engines, each with its own compressor. The syren is connected to an air receiver of 8 cub. m. capacity. A series of radio lighthouses had been installed in Spain. These emitted various notes, on a wave length of 1,000 m., with characteristics corresponding to the characteristics of the lights at which they were installed. The lighthouse at Finisterre which operated with a modulated spark gave equi-distant emissions, of 500 vibrations per second, every 7 seconds, emission lasting half a second, while the lighthouse at Villano, with similar plant, gave groups of two emissions of 600 vibrations per second, lasting 1 second, the emissions being separated by a silence of 7 seconds and the groups by a silence of 21 seconds. These radio signals corresponded in a general way with the light-signals, Finisterre has a fixed light varied by equidistant flashes, for which reason the waves sent out by the radio apparatus were also equidistant while Villano has two groups of flash lights, to which its radio signals corresponded. It was proposed to instal 26 such radio stations along the coast of Spain, and the report urged that radio compasses should be fitted on board ships, for the directive reception of such signals. It was claimed that the signals did not materially interfere with commercial wireless stations.

The report from the United States was written by Mr. George R. Putnam, the Commissioner of Lighthouses. It formed a review of the progress of sea marks in the United States over the last ten years and stated that the most important advance lay in the establishment of radio fog signals. Three such signals were placed in commission in the vicinity of New York Harbour in May, 1921, and a number of additional stations had since been established or were in progress. Each station automatically sent out 1 000-m. wave-length signals with distinctive characteristics during periods of fog or low visibility. The signals were used by vessels equipped with radio compasses and reliable results were being obtained. Among other fog-signalling arrangements four aerial bells operated by carbon dioxide gas had been installed on buoys and beacons and had resulted in a large saving. One of them had been in commission for nearly four years. The bells were installed in connection with automatic gas lights and had replaced apparatus requiring much more attendance. The gas was compressed in flasks and one charge operated for about 4 months. The signals operated continuously, but a device for rendering the signals inoperative in clear weather was being tested. A great advance had been made in the number of lighted buoys, and there were now 638 in service. The most efficient type had proved to be that employing dissolved acetylene.

The United States Lighthouse Service had 117 tenders and lightships in commission. The latest lightships were provided with propelling machinery, usually steam plants burning oil, but Diesel engines were being installed on several vessels under construction. On new ships the illuminant was incandescent electric lamps or acetylene, and the principal ones of each type were equipped for wireless communication. The greatest change in lighthouse construction during recent years had been the more extended use of reinforced concrete, seven such lighthouses having been constructed. One on Navassa Island in the East Indies on the route to the Panama Canal has a cylindrical tower, 15 ft. in diameter and 162 ft. high. Reinforced concrete had also been largely used for foundation caissons for lighthouses and beacons. The United States Lighthouse Service maintained 16,373 aids to navigation which was probably the largest number under one control. There had been an increase of 28 per cent. in the last ten years, in which time the number in Alaska had been more than doubled. Mr. Putnam finally referred to the international aspect of coast lighting, and stated that for the whole world in 1915 there were 13,226 light stations, 290 lightships and 1,586 fog signals. Of the lights about 10,000 were on the coasts of Europe, the United States and Canada, leaving but a small proportion for all the other coasts. Some places with considerable traffic were inadequately marked as, for instance, the coasts of the Caribbean Sea and the West Indies, which had become of increased importance on account of shipping passing to and from the Panama Canal.

In the French report, compiled by MM. M. Blondel, Attaché au Service des Phares et Balises, and A. de Rouville, Ingénieur, en Chef du Service des Phares et Balises, various optical apparatus was first described and the best arrangements to be used with incandescent electric lamps was discussed. Sound signalling was then dealt with, and it was pointed out that the development of wireless fog signals had in no way eliminated the necessity for such sound signals which always acted as a standby to more delicate apparatus and in any case were of great value to small coasting and fishing boats. The leader cable also, despite its inconveniences, appeared to justify itself for tortuous approaches to large ports owing to its accuracy. The cables were costly, running to from 20,000 francs to 30,000 francs per kilometre. For radio signals MM. Blondel and de Rouville gave preference to arrangements which placed responsibility for the guidance of the ship on the mariner. It was very desirable however, that some international agreement should be come to in connection with the system to be adopted, in order that shipowners would not be called upon to equip their vessels with a multiplicity of apparatus.

Of the five papers from Great Britain the first was contributed by Mr. Hood, the general reporter, and formed a comprehensive treatise on the most recent lighthouse work carried out or contemplated by Trinity House. Much of the paper was of too technical and detailed a nature to be effectively dealt with in a short summary. In connection with the lighting of buoys it was stated that the first trial of dissolved acetylene gas as an illuminant was made by Trinity House on a buoy manufactured by the Gas Accumulator Company, and laid at the Bahama Bank of the Isle of Man in 1915. So successful did this buoy prove that of 131 lighted buoys round the English Coast under the jurisdiction of Trinity House, 37 consume dissolved acetylene gas on the A.G.A. system. Trinity House had adopted as a standard for buoy lighting a gas cylinder, or accumulator, of 17,000 litres capacity, which was able to maintain a burner for twelve months at sea without recharging. This meant a considerable saving to the attendant steam vessels in time and coal, as compared with the visit every month or two to the oil gas buoys. It was not contended that dissolved acetylene was the best illuminant for all unwatched lights, as the cost of the gas was high, and where a large consumption was required and periodical attention could be given it was considered preferable to generate the acetylene gas on the spot. Trinity House had already adopted this principle at the Inner Fern and Bamburgh lighthouses, off the coast of Northumberland, and had approved a scheme for generating gas from carbide in the two leading lights at Hurst on the mainland opposite the Isle of Wight. The lights at present had oil burners, and the change would convert them from watched to unwatched lights. The burners would be of the upright triple-mantle type, so that in the event of one mantle breaking, two would still remain illuminated until the visit of the attendant.

Mr. Hood then went on to say that although acetylene was the most suitable illuminant for shore lights where no continuous watch was kept, for cases in which the light was of sufficient importance to warrant the presence of keepers, the adoption of paraffin as an illuminant was almost universal. He then went on to refer to the Hood petroleum vapour burner, an illustrated description of which appeared on page 541 of our issue of May 5, 1922. He then went on to say that electric light was employed at three Trinity House lighthouses. For those at the Lizard and St. Catherine's Point the current was generated on the spot. This system was expensive and necessitated an engineer and four or five keepers as *personelle*. The same arrangement

was originally used at the South Foreland lighthouse, but the generating plant had now been abolished and connection made to the Dover Corporation Electric Supply, a 2,000-volt cable having been laid to the lighthouse, where transforming plant was installed. A 4 kw. gas-filled lamp of 8,000 candle power was used for the light. The bulb was 11½ in. in diameter and contained a spiral filament in the shape of a cross. In the other two lights arc lamps were still used.

After dealing with the work of Trinity House in connection with sound signalling and describing the wireless telephone installations with which the lightships are being equipped in place of the older submarine cable which was costly to maintain and gave some trouble, Mr. Hood referred to wireless fog signals and expressed a preference for an arrangement by which the navigator received a wireless signal from which, without any reference to a wireless operator, he could determine his bearings as he did with his compass on a light or daymark. Of the various systems which had been submitted to Trinity House the three which appeared to commend themselves as being steps in the right direction were, first, two small frame aerials of different sizes fixed at right angles to each other and capable of rotation on the top of a ship's charthouse. The aerials could be made to assist or oppose each other, and the bearing of a transmitting station was read off by rotating the aerials. The second system consisted of a rotatory frame aerial on shore from which the length of the emitted wave was constantly varied, each individual wave representing definite true or magnetic bearings which could be ascertained by the ship's wireless installation. The third method was the short wave Marconi beam which was generated at the focus of a revolving parabolic mirror. This apparatus required a special receiving set, and had been installed experimentally at Inchkeith. Each system had its respective merits, but the whole question would ultimately require investigation by an International Commission with a view to fixing on a standard.

The next report from Great Britain was by Mr. Arthur E. Butterfield, Engineer-in-Chief to the Humber Conservancy Board. This report dealt entirely with proposals for a uniform system of lighting entrances and tidal rivers, and lay somewhat outside our field. It was interesting to note, however, in view of the subsequent discussion of the subject that Mr. Butterfield reserved green coloured lights for wreck-marking purposes. The next report was by Messrs. Walter J. Curtis and Robert Steel, and was devoted to a description of the A.G.A. system of lighting by dissolved acetylene. The gas was stored in steel cylinders which were filled with a substance so porous that only 20 per cent. of the volume was really occupied. The porous mass was of a ceramic type, and its purpose was to prevent the rapid spread of the gas and the substance in which it was dissolved in case of disruption of the cylinder. The substance used for dissolving the gas was usually acetone. The Sun-valve was an interesting feature of the apparatus, and controlled the light in terms of daylight or darkness. The extreme lift of the valve was $\frac{1}{4}$ in. and it was operated by a tube which expanded or contracted as it was exposed to daylight or darkness.

The next report from Great Britain was written by Mr. D. Alan Stevenson and was concerned with fog signals, the author expressing the opinion that it was unlikely that wireless or other new forms of fog signals would eliminate sound signals. Particular reference was made to the automatic acetylene fog gun. The apparatus was worked entirely by the pressure from acetylene gas generated from carbide and water, and although it could not be compared in power with a syren compressed air signal, it was the only existing type of powerful automatic fog signal. An explosion could be obtained as frequently as every 20 seconds. The last British communication, written by Captain Harold Browne, dealt with marine sound ranging or "the radio-acoustic method of fixing the position of a ship at sea." It explained the method of determining the position of a vessel from shore by observing the time taken for submarine sound waves to travel from the vessel. Two or more hydrophones were placed close in-shore and were electrically connected to a shore observation station. A vessel requiring her position communicated the fact by wireless to the shore station and then exploded a small depth charge, simultaneously transmitting a wireless dash. The observer recorded the time the dash was received and the time each microphone indicated reception of the sound signal from the depth charge. From these data, the velocity of sound in sea water and the position of the hydrophones, the bearing of the signal of the mid point between any two hydrophones could be calculated. The bearings were then plotted on a chart and the position of the vessel thus ascertained communicated to the ship by wireless.

A long Italian report was presented by Lieutenant Colonel Dr. A. Luria, Attaché technique au Service des Phares et Signaux Maritime. It dealt in considerable detail with the characteristics of different types of lighthouse luminaries, the development of optical apparatus, fog-signalling of various types, &c. Incidentally it was mentioned that some day-mark beacons were coated with phosphorescent varnish in order to make them visible a certain distance at night. The Japanese communication was by Dr. Genji Ishikawa, Engineer of the Department of Communications of Tokio. It surveyed the growth in the number of lighthouses in Japan during the last fifty-five years and mentioned a process for the automatic generation of gas at a pressure of two atmospheres. The gas was used with incandescent mantles, 25 mm. to 35 mm. in diameter, and a total light of 500 candle power to 800 candle power was obtained.

The report from Holland was by Mr. P. van Braam van Vloten, Chief Engineer of the Lighthouse Service of Holland. It was principally concerned with the work done by the Netherlands Lighthouse Service in utilising incandescent electric gas-filled lamps for improving the coast lighting of Holland. As ordinary gas-filled lamps were not suitable for use in lenticular optics, trials were made in conjunction with Messrs. Philips, of Eindhoven to secure suitable filaments, with satisfactory results. The type of filament approved for high-power lamps taking from 30 amperes to 50 amperes at 80 volts was disposed in two vertical planes cutting one another along the vertical axis of the lamp. For smaller lamps of 75 watts to 1,000 watts a filament in the form of a truncated cone was used. The electric arc lights in the lighthouses at Terschelling, Ymuiden and Westkapelle, had been replaced by lamps of the first type. The visibility remained practically as before, and as the lamps did not require constant attention it had been possible to reduce the *personnel* at the lighthouses. The introduction of similar lamps into lighthouses having petroleum vapour burners very considerably increased the range of light and reduced the cost of maintenance. The economy of these lamps became very marked when the lighthouses could be connected to a local electric supply, as the staff could then be reduced to one man, an automatic apparatus being installed to ensure continuity of light in the event of failure of the electric supply.

The next report was from Sweden and was written by Mr. Folke Lundeberg, chief engineer of the Royal Swedish Board of Administration of Light, Pilotage and Life Saving. It contained an account of the A. G. A. lighting system which is almost universally adopted in Sweden, and pointed out the necessity for proper charging and general care of acetylene gas cylinders. After the irregular working of two gas cylinders at Karlskrona Harbour in 1918, all the apparatus supplied in connection with the plant was carefully tested. It was ultimately found that impure acetone had been used in the cylinders. They had fouled the acetylene gas and caused a fatty and viscous coating on the vital parts of the Dalen gas flasher. The accumulators had been manufactured by the Swedish Gas Accumulator Company and were entirely satisfactory, but had been repeatedly re-acetoned at a small gas charging station not under the technical control of the manufacturer of the accumulators. The final report was from Russia and was written by Mr. J. de Schokalski. It was particularly commended by Mr. Hood as being an account of failure, and consequently probably of more value to other engineers than are the usual accounts of uninterrupted success. Unfortunately, however, little technical detail was contained in the report and it would be difficult to apply the lesson it taught elsewhere. It concerned two unsuccessful attempts to establish an unwatched light on the Two Brothers Reef off Bakou in the Caspian Sea, both beacons having successively been destroyed by gales. The reef was about 11 ft. above sea level and the first tower, of lattice type, was 33 ft. high and was erected in 1911. During the autumn gales of the same year it was destroyed. In July, 1912, a second tower of the same type but of stronger construction was built but met with the same fate in six months time. A third tower still more stiffly built and reduced in height to 28 ft. was now under construction and it was hoped to commence erection shortly.

A comparatively short period was available for the discussion of the reports on this question as the last two communications on the Ocean Navigation Section were dealt with in the morning of July 6th. Captain C. L. Hussey, of the U.S. Navy opening the discussion on this question of coast lighting and signalling said that the international aspect of underwater sound signals should receive more attention. The apparatus had been developed to a point at which it might well be adopted by all nations. Several thousand ships had been equipped to take advantage of it and an international code should be adopted for its use. Sir Acton Blake, Master of Trinity House, spoke about buoyage and the colour of buoys, and pointed out that any universal system was almost an impossibility owing to the variation of local conditions. Colour was always a difficulty and he was interested in being able to announce that Trinity House had that day got a new agreement into shape which eliminated green light except for the starboard light of a ship and for marking wrecks.

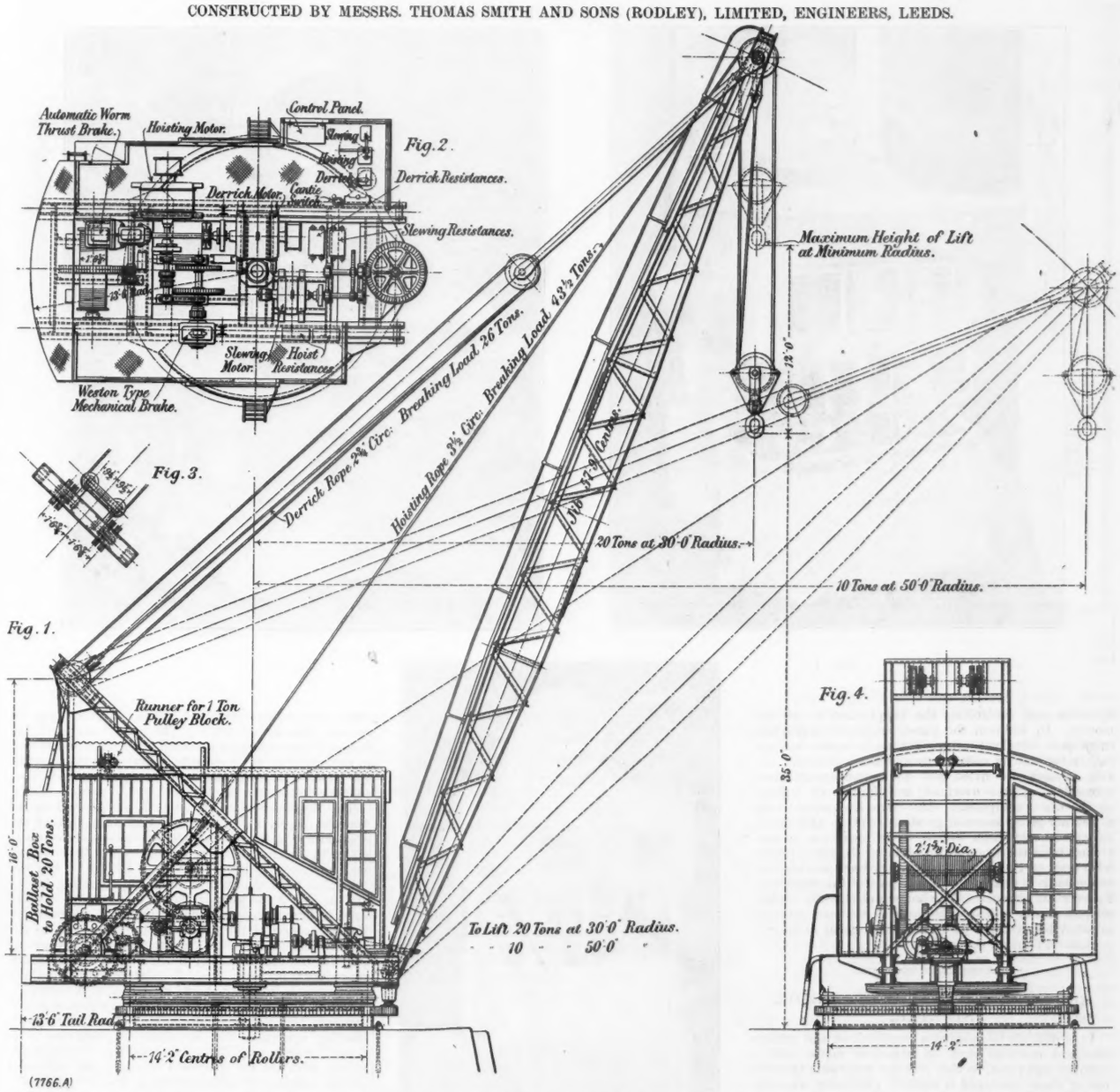
Mr. G. R. Putnam, Commissioner of Lighthouses of the U.S. Department of Commerce, pleaded for a more extended use of radio signals. There was still much room for development and there were some five or six systems in use. The best system could only be developed by experience and tests and it was desirable that more should be done in practice. At future conferences full opportunity should be given to discuss this question. Even a special section on lighthouse problems would find plenty to do. Captain Harold Browne said that only the previous week one of the cross-channel steamers was ashore under Dover cliffs, showing that there was still much room for progress in this question even in well-equipped and narrow waters like the Channel. The methods of signalling could be divided into three groups, the first, wireless, being most useful when a ship was a long way from land, the second, sound ranging, when she was a moderate distance away and the third, the leader cable, when she was close in. He thought the most dangerous position was the medium one, and if he had to confine himself to one system of signalling he would choose sound ranging. Several other speakers also made brief remarks, and many referred to the importance of the subject and to the desirability of more time being given for its discussion at future congresses.

The discussion of coast lighting closed the sectional proceedings of the conference, but a full session was held on the afternoon of the 6th inst., when the various resolutions passed by the sections were submitted to the full congress and approved. Various complementary speeches and votes of thanks concluded the proceedings.

WORK ON OILFIELD EMULSIONS.—In fields where water is produced with oil, water and oil emulsions are frequently formed. These emulsions are generally very stable in character, and unless broken down are of no value. In the years 1920 and 1921 about 70,000,000 barrels of "cut" or emulsified oil were produced in the Gulf Coast fields in the United States, and about 35,000,000 barrels of "cut oil" were produced in the mid-Continent field. More than half of this cut oil was treated and broken down into "good" oil and water, resulting in a saving of approximately 50,000,000 dols. during that period. The remainder of the cut oil was either burned, left in earthen storage, or lost by drainage into streams. The Bureau of Mines is now studying, at Bartlesville, Okla., field methods used for the recovery of oil from these emulsions. Different methods of treatment have individual advantages in different fields. The object of the Bureau of Mines experiments is to determine the most efficient and economical methods of treating cut oil produced in the various fields, and to obtain data regarding plant construction, operation and details of cost.

20-TON REVOLVING WHARF CRANE AT VERNON-ON-SHORE.

CONSTRUCTED BY MESSRS. THOMAS SMITH AND SONS (RODLEY), LIMITED, ENGINEERS, LEEDS.



(7766.A)

A FIXED wharf crane recently installed by the Admiralty at their naval establishment, Vernon-on-Shore, and built by Messrs. Thomas Smith and Sons (Rodley), Limited, of Rodley, near Leeds, is illustrated in the detail drawings forming Figs. 1 to 4 on this page, while a general view of the crane in position is given in Fig. 5, on page 84. The crane is of the three-motor type, and will lift 20 tons at 30-ft. radius and 10 tons at 50-ft. radius, or a test load of 30 tons. The jib is of the double lattice type and is 57 ft. 9 in. long, giving a height of lift of 35 ft. at 50-ft. radius and 47 ft. at 30-ft. radius. As will be seen from Figs. 1 and 5, the derricking rope is reeved round pulleys carried on the crane superstructure, as shown in Fig. 3, and on the tie rods. This arrangement ensures even distribution of the load. The derricking motor is of 35 b.h.p., and a load of 10 tons may be derricked from 50 ft. to 30-ft. radius in 1½ minutes.

The hoisting motor is of 50 b.h.p., and the crane will lift 20 tons at 20 ft. per minute and 10 tons at 40 ft. per minute. Slewing with a load of 20 tons may be accomplished through a complete revolution in 1½ minutes, the motor being of 12 b.h.p. The arrangement of the motors and gear on the superstructure platform is shown in Figs. 6 to 8. The superstructure revolves on a ring of live rollers and is driven from a cast steel rack formed in segments. The bottom circular member which carries the central pin, rack and roller path, is built up of steel sections. For hoisting change gear is provided to give fast and slow speeds for the 10-ton and 20-ton loads, respectively, while creeping speeds can be obtained by means of resistances in the rotor circuit of the hoisting motor. This allows of the hoisting or lowering of a load of 20 tons at 2 ft. per minute. The spur wheels and pinions of the various gears have teeth machine-cut from the solid, the pinions being of forged steel and the spur wheels of cast steel. The worm wheel of the derricking motion is fitted with a phosphor-bronze rim. The braking arrangements of the crane consist of an automatic mechanical brake of the Weston type, on the hoisting mechanism, which is sufficiently powerful to hold the test load and an automatic solenoid brake on the hoisting motor spindle. The derricking motion is also provided with two brakes, one being an automatic worm thrust brake and the other a solenoid brake on the motor spindle. The slewing motion is fitted with a foot brake which is strong enough to hold the jib against maximum wind pressure. A cut-out switch is fitted in conjunction with the hoisting solenoid brake so that current may be cut off from it and the load lowered against the action of the brake.

The crane is supplied with three-phase 50-period current at 415 volts, and the slip-ring motors are of the drip-proof type fitted with phosphor-bronze bearing bushes. They do not vary in speed more than 2 per cent. to 3 per cent. between no load and full load, except, of course, in the case of the hoisting motor, when the creeping resistance is brought into use. Overwind switches are provided in connection with the hoisting and derricking motions which trip the main circuit-breaker in the event of the load being carried above or below predetermined points, or the jib derricked in or out beyond its proper range. The motor controllers are of the reversing drum type fitted with spring crank handle return, and the hoisting and slewing controllers are fitted with universal operating levers, the connecting gear being so arranged that the motion of the handle is in the same direction as the motion of the load. The resistances are 5 minutes rated and are proportioned to give a temperature rise not exceeding 200 deg. F. A 125-ampere switch panel is fitted to the crane, the panel, which is provided with a steel cover at the front and sides, containing a three-pole contactor type circuit breaker fitted with magnetic

OIL-IMMERSED STAR-DELTA MOTOR STARTER.

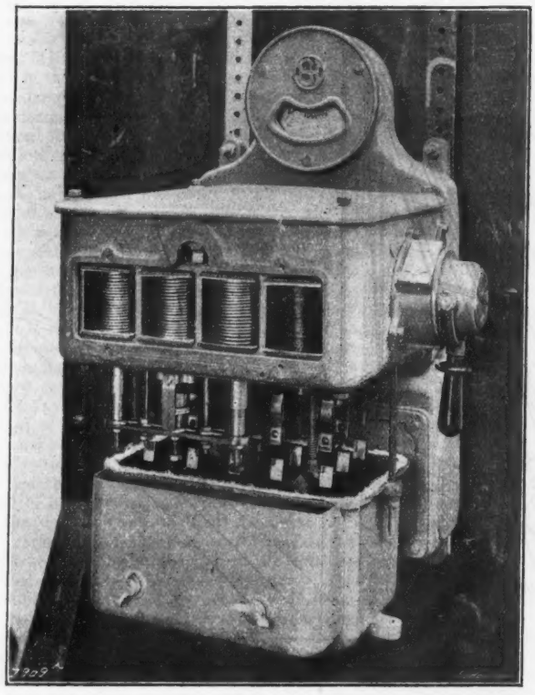


FIG. 1.

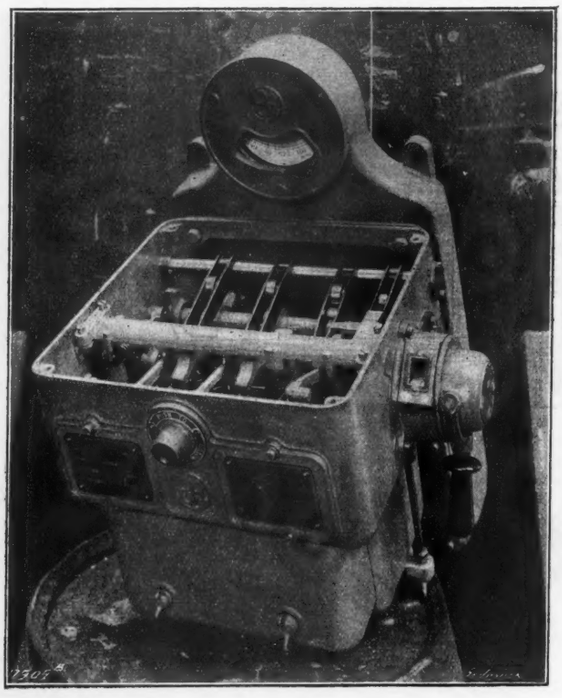


FIG. 2.

blow-out and controlling the supply line to all the motors. In addition the panel contains independent single-pole overload relays for each motor circuit, each relay having coils in two separate phases. No-volt releases are fitted and the arrangement gives protection against overload and failure of voltage on the whole equipment. The crane is equipped with a weather-proof house of good appearance and finish, as will be seen from Fig. 5. The operation is controlled from the front of this house. Inside a runner with a set of 1-ton pulley blocks has been provided for use when it is desired to lift any part of the machinery for overhaul or repair. The house is electrically heated, while a cluster of 50-c.p. lamps in a yard-arm reflector is fitted beneath the jib in such a position as to give maximum light on the hook.

OIL-IMMERSED STAR-DELTA MOTOR STARTER.

IT is difficult to imagine a more robust and reliable electrical machine than an induction motor with a squirrel-cage rotor, so that it is not surprising that the use of these machines is steadily extending wherever a polyphase power supply is available. Their drawbacks, in comparison with direct-current machines, are, of course, the heavy starting current taken and the absence of speed regulation, but for numerous industrial applications these features are of little importance, and in such cases the squirrel-cage induction motor forms an almost ideal source of power. It will be obvious, however, that in order to obtain a high degree of reliability for the whole power unit, the design of the switchgear for starting and controlling the motor must be no less substantial than that of the motor itself, since a breakdown in either will have the same effect in shutting down the machine or plant operated by the motor. This fact is now fully realised by all reputable manufacturers of switchgear, and has led to a marked improvement in the design of such gear within recent years.

Messrs. Brookhirst Switchgear, Limited, Northgate Works, Chester, whose apparatus for starting and controlling direct-current motors has a high reputation for efficiency and reliability, have been considering the design of similar apparatus for alternating-current motors for some years, and as a result of their investigations have just placed upon the market a series of oil-immersed controllers of the direct-connection, star-delta and auto-transformer types for induction motors

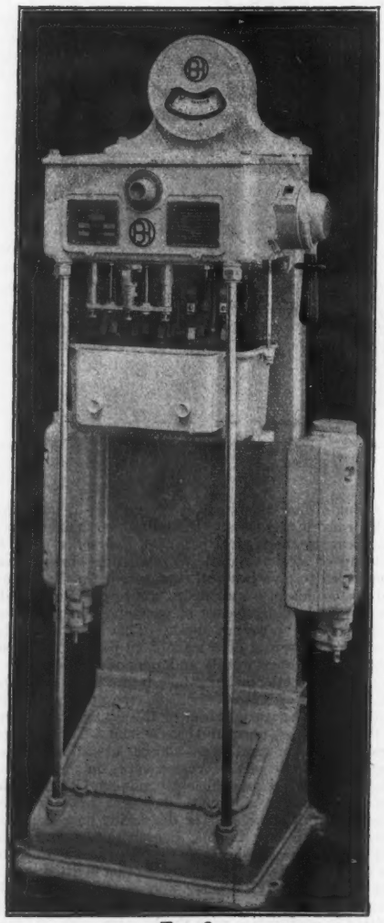


FIG. 3.

with squirrel-cage rotors and of the resistance type for motors with wound rotors. The main features of the design of the apparatus are similar for all types, so that in describing it we propose to confine our attention to the type of starter most commonly employed, viz., the star-delta type.

This we illustrate in Figs. 1 to 7, on this and on the opposite pages, Fig. 1 showing the main part of the apparatus with the oil tank lowered to show the contacts and with the front cover removed to show the overload and no-voltage release solenoids. In Fig. 2 the top cover has been removed to show the operating levers, and in Fig. 3 the gear is shown mounted on a pillar so as to form a complete control unit with provision for the connection of the cables to the mains and to the motor. The design and construction of the essential parts of the gear is clearly illustrated by the drawings reproduced in Figs. 4 to 7. Before describing the apparatus in detail we should explain that it comprises a circuit breaker which is closed first, a switch which connects the stator windings in "star" during the starting operation and a switch for changing over from "star" to "delta" connection for running; all the switches are composed of triple-pole units and all the contacts are oil-immersed as will be understood from the illustrations. It will be remembered that, when connected in star, the voltage across each phase of the windings is only $\frac{1}{\sqrt{3}} = 0{\cdot}578$ of the line voltage per phase, and this fact materially reduces the starting current.

The essential feature of the Brookhirst starter is, however, the employment of a form of overload release which allows a heavier current to pass during the starting operation than when the motor is running normally, but provides the necessary degree of protection under both conditions. In some types of starters for motors of this class, the overload trips are rendered inoperative while starting up and in others time lags are fitted to delay the action. The former arrangement has the obvious disadvantage that while starting, the motor is quite unprotected against heavy overloads or even short circuits, and certain difficulties attend the use of time lags in this connection. Time lags having an "inverse time" feature will, of course, allow the trips to operate instantaneously on a short circuit, but the motor will remain unprotected against any smaller degree of excess current for the period during which the action is delayed by the time lag. With the maximum adjustment of the time setting, the

OIL-IMMERSED STAR-DELTA MOTOR STARTER.

CONSTRUCTED BY MESSRS. BROOKHIRST SWITCHGEAR, LIMITED, ENGINEERS, CHESTER.

Fig. 4.

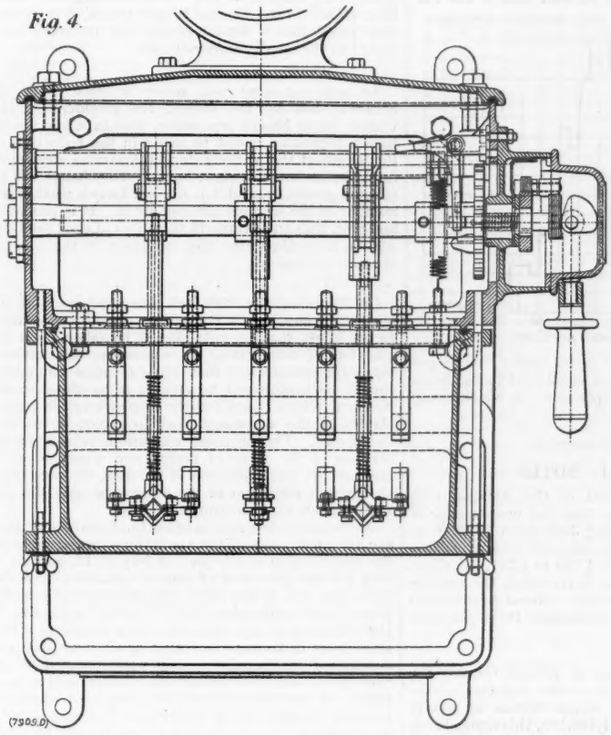


Fig. 5.

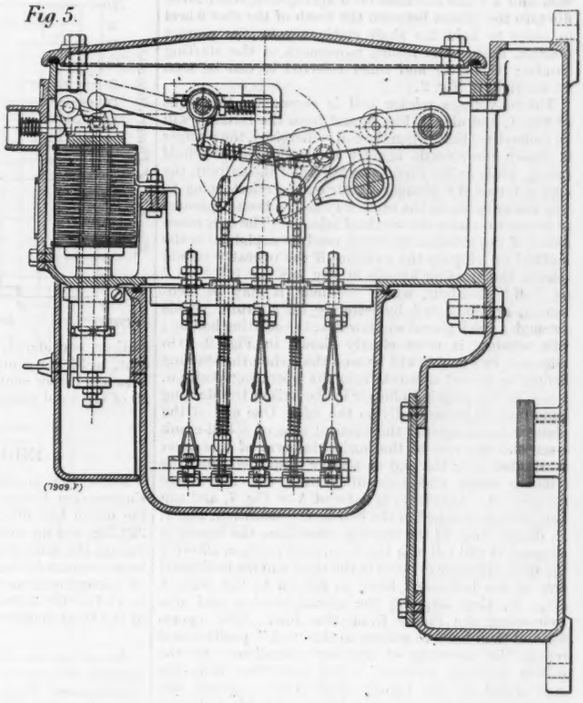


Fig. 6.

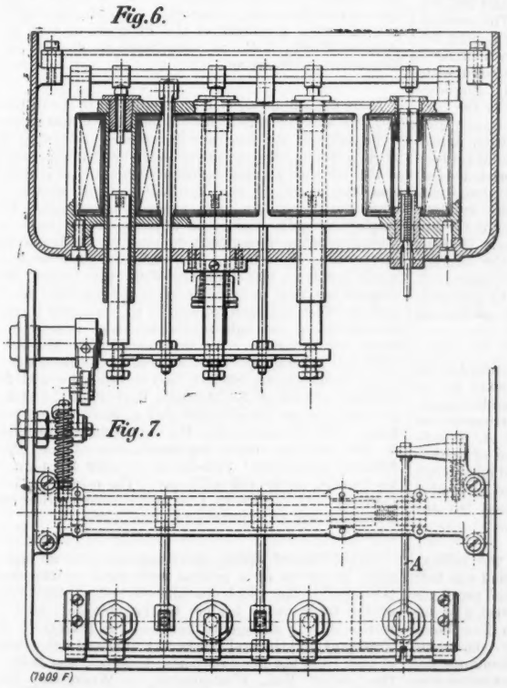


Fig. 7.

delay period will probably be less than the time required for starting, so that the overload trip will operate, and a further difficulty arises from this cause. When starting up under light load, the current peak will be greatest when the star connections are made, but when the motor is driving a machine, such as a centrifugal pump, in which the load increases as the motor accelerates, the current peak may be heaviest when the delta connection is made. In this case, if the maximum time setting of the time lags is not sufficient to allow the current to die down it will be necessary to increase the current setting of the overload device, and this involves a sacrifice in the degree of protection obtained, not only during the starting period, but also under running conditions.

In the starter to which we are now referring, these difficulties have been overcome by the provision of a device which automatically lowers the iron plungers of the overload release solenoids during the operation of starting and restores them to the normal position for running. The means employed to effect the change in position of the plungers will be described later, but it will be evident that, when the plungers are lowered, a heavier current will be necessary to pull them up and operate the overload trip than will suffice to raise them from the higher position in which they are left under normal running conditions. This position can, of course, be adjusted in the ordinary way to limit the overload current to the desired proportion of the normal running current.

The main operating mechanism is best shown in Figs. 4 and 5, which are, respectively, a longitudinal section and a transverse section through the gear. It will be seen that the movable contacts are in the form of copper wedges mounted on tee pieces on the lower ends of vertical steel rods. The fixed contacts, most clearly shown in Fig. 5, consist of copper blocks attached to copper laminations and backed with flat phosphor bronze springs in the smaller sizes and with steel springs in the larger sizes. The contacts are completely immersed in oil contained in a cast-iron tank which can be lowered for inspection purposes as shown in Fig. 1. Each pair of vertical rods carrying the movable contacts is connected at the upper end to a crosshead which is pivoted to a lever formed of a pair of steel plates and mounted on a shaft, shown in section in Fig. 5; the levers, however, are more clearly visible in Fig. 2. Cams mounted on the main operating shaft, which is the lower one of the two shown in Fig. 4, engage with rollers on the steel plate levers when the operating shaft is rotated, and by this means the levers are raised, drawing up the vertical rods and closing the switch contacts. The sequence of closing the switches is, of course, dependent on the angular position of the cams on the main shaft, and is entirely independent of the will of the operator.

The right-hand switch functions as a "free handle" circuit breaker, and when closed, is retained in that position by means of a trigger, shown in Fig. 5. This trigger engages with a pin on the end of the steel plate lever, but is released when the plungers of the overload coils are drawn up, thus allowing the circuit breaker to be returned to the open position by the helical springs mounted on the vertical rods. The mechanism for effecting this release will be clear from an inspection of Fig. 5 without further explanation, but it should be mentioned that the normal method of stopping the motor is to operate the trigger by means of the push button shown on the front of the casing in Fig. 2, and also shown in section in Fig. 5.

The main camshaft is operated by an external handle, seen on the right of the casing in Figs. 1, 2 and 4, and connected to the camshaft by means of a pair of spur gears. To start the motor, the handle is first raised into the operating position and then moved backwards and forwards to operate an internal ratchet gear. This permits the shaft to turn in one direction only and also limits the speed at which the starting operation can be carried out, since if moved too rapidly centrifugal force will cause the pawl to fail to engage with the ratchet teeth. Continued movement of the handle first closes the circuit breaker, then the star-connection switch and afterwards the delta-connection switch, but, immediately before the closing of the latter, the star-connection switch is opened. The star-connection switch is opened and the delta-connection switch closed during the same ratchet movement, but the cams are so arranged that the former must have actually opened before the latter makes contact. The opening of the star-connection switch is effected in a positive manner by means of a projection on the cam, which strikes the end of the steel-plate lever, so that if by any chance the star switch should have welded up, the delta switch cannot be closed so as to produce a dead short circuit. After the delta switch has been closed, an additional cam on the left-hand end of the camshaft raises the cores of the overload-release solenoids into the running position. This cam can be seen at the extreme left of the shaft in the half-tone illustration (Fig. 2), and the whole of the mechanism can be followed by an examination of the drawings reproduced in Figs. 5, 6 and 7.

It should here be mentioned that, in order to prevent the change from star to delta connections from being made too rapidly, the cams are so arranged in

conjunction with the ratchet gear that it is necessary to make three forward movements of the starting handle between the closing of the star-connection switch and that of the delta-connection switch. Another point to which attention may be called is the fact that a star wheel is fitted on the camshaft at the right-hand end, and a roller mounted on a spring-controlled lever fits into the spaces between the teeth of the star wheel in order to hold the shaft stationary in the correct position during the return movement of the starting handle; the lever and roller referred to can be seen on the right of Fig. 2.

The no-voltage release coil is shown on the right of Fig. 1, and also in Fig. 6, and from the latter it will be understood that, when the coil is energised, the plunger is drawn downwards against the action of a helical spring, while in the event of a failure of the current, the spring forces the plunger upwards, the effect being to trip the switches in the same way as has been explained in connection with the overload release. The only other detail of the mechanism which need be explained is the method of tripping the switches if the operator should release the starting handle in any but the full "on" or "off" positions, which positions, it may be mentioned, are indicated by lettering on a drum, visible through a small glazed window near the starting handle; this window is most clearly shown in Fig. 2. On reference to Fig. 4 it will be seen that when the starting handle is moved upwards into the operating position, a cam moves a spring plunger in the axis of the starting handle shaft horizontally to the left. One end of the plunger bears against the vertical arm of a bell-crank lever and the end of the horizontal arm of this lever is situated over the end of a lever connected with the tripping shaft and extending over the no-voltage release coil. This lever is lettered A in Fig. 7, and can also be distinguished in the half-tone illustration, Fig. 2. If, in any stage of the starting operation, the handle is released, it will fall into the downward position allowing the spring plunger to move to the right and the horizontal arm of the bell-crank lever to fall on to the lever A (Fig. 7), thus tripping the circuit-breaker and disconnecting the motor from the line. The operator will then have to return to the "off" position and repeat the sequence of starting operations. In the full-on position, however, a pin projecting from the gear wheel on the handle shaft comes opposite the vertical arm of the bell-crank lever and holds it clear of the tripping lever.

The gear, as illustrated in Figs. 1 and 2, is provided with a moving-iron ammeter and forms a complete, self-contained starting unit for fixing to a wall. A terminal box is provided at the rear of the oil tank as shown in Fig. 5, and the leads from the mains and to the motor are brought into this box through bushed holes in the bottom. In Fig. 3 the same gear is shown mounted on a pillar having a cast-iron hollow base, while the back consists of a shallow box constructed of welded steel plates. Split cast-iron cable boxes, suitable for armoured or other cables, are bolted to the sides of the pillar, as shown in the illustration, for the connections from the mains and to the motor, and the interior of the pillar forms a convenient protection for the internal connections to the switches; doors are provided in the back of the pillar to give access to the connections. If required, an isolating switch can be mounted in the base of the pillar, and, when this is provided, mechanical interlocks are fitted to prevent the oil tank from being lowered, or any of the covers from being removed, unless the isolating switch is open; the pillar illustrated, however, is not so fitted.

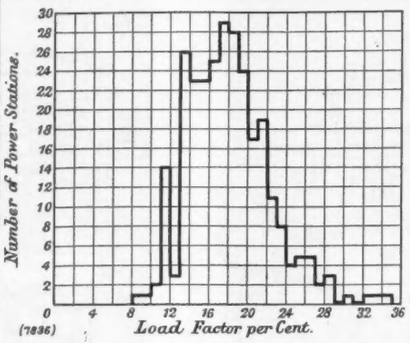
Starters of the type described above are made in standard sizes for motors up to 125 h.p. and for pressures up to 650 volts, but they can be supplied for higher powers and pressures if required. They are suitable for all industrial requirements and comply with the Home Office regulations for use in non-fiery mines. As previously stated, similar starters are made of the direct-connection, auto-transformer, and rotor-control types, but the two last-mentioned are supplied in pillar form only.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—On the invitation of Mr. George Hughes, past-president of the above-mentioned association, arrangements have been made for members to visit the locomotive works of the London, Midland and Scottish Railway at Horwich, on Thursday next, the 26th inst. The members will travel by a special train leaving Victoria Station, Manchester, at 2 p.m.

THE BRADFORD ENGINEERING SOCIETY.—We have received a copy of the proceedings of this society for the session 1920–21, containing reprints of papers on "Steel-Making Processes," by Mr. C. K. Everitt; on "Low-Temperature Carbonisation," by Dr. T. M. Davidson; on "Steam Meters," by Professor G. F. Charnock; on "Fine Measurements," by Mr. V. I. Norbury Williams; and on "Condensing Plant," by Mr. J. E. Johnson. The meetings of the society are held at the City of Bradford Technical College, and the address of Professor G. F. Charnock, who acts as honorary secretary, is 30, Pemberton-drive, Bradford.

FREQUENCY CURVE OF BRITISH POWER STATIONS.

THE accompanying diagram shows in graphic form the relative numbers of British power stations with various load factors. It will be seen that of the 277



stations considered, the load factor varies from 8 per cent. to 35 per cent., the most usual load factor being between 17 per cent. and 18 per cent., in which group 29 of the total number of stations are to be found.

INDUSTRIAL NOTES.

FROM the monthly journal of the Amalgamated Engineering Union we learn that the membership of the union has declined during June from 304,930 to 293,758, and the number of branches shows a reduction, during the same period, from 1,799 to 1,781. A slight improvement in employment is recorded, the number of unemployed members having declined from 44,190 to 42,116, the latter figure representing 16·33 per cent. of the total membership.

According to the *Ministry of Labour Gazette*, the number of persons recorded on the registers of the Employment Exchanges in Great Britain as wholly unemployed on July 9, was 1,189,100, this figure being 2,250 less than that for the preceding week and 296,778 less than that for January 1 of this year. The number of persons working short time and drawing benefit for intervals of unemployment has, however, increased somewhat, being 63,200 on July 9 as compared with 63,150 on July 2, and 56,261 on January 1. Employment during June has been generally good in the coal mining, tin-plate and sheet-steel manufacturing and carpet industries; fairly good in the tailoring, paper, coachbuilding and certain sections of the metal trades; and fair in the furnishing, printing and brick trades. In most of the other large industries employment was slack, although slight improvement in the building trades has been reported; employment in the wool, textile and hosiery trades declined somewhat. Returns received from trades unions show that the average proportion of unemployed members was 11·1 per cent. at the end of June, as compared with 11·3 per cent. at the end of May and with 15·7 per cent. at the end of June, 1922.

The debate on Mr. Philip Snowden's motion for the gradual supersession of the capitalist system by an industrial and social order based on the public ownership and democratic control of the instruments of production and distribution, and on Sir A. Mond's amendment to the effect that the abolition of private interest in production and distribution would impoverish the people and aggravate existing evils, was concluded in the House of Commons on Monday last, but the motion was defeated by a majority of 247.

A meeting of the representatives of the railway companies and of the trades unions concerned was held on Tuesday last to consider the companies' proposals for a modification of the conditions of service of the traffic and clerical staffs. According to *The Times* labour correspondent, the preliminary discussion turned mainly on the necessity for the demands put forward by the companies in order to effect economies which will permit a further reduction of freight rates and other charges. The principal demands are the abolition of special pay for night duty; payment of time and a-half for Sunday work, with a minimum payment for two hours; abolition of present service scales of daily wages and the basis of mileage payments for drivers and firemen, and the substitution of a scheme of classification involving a reduction of 2*s.* a day on the maximum for shunting drivers and motor men, but giving 1*s.* a day extra for certain classes of drivers; and the withdrawal of the remaining war bonus under sliding-scale provisions.

The union representatives argued that the financial position of the companies did not warrant any attack on the railwaymen's condition, and that the latter should rather be improved. Certain counter-proposals were then put forward on behalf of the men, but agreement being impossible the companies will now refer their claims to the Central Wages Board. It is also anticipated that a similar course will be taken with regard to the men's counter-claims.

An announcement was made in New York on Saturday last by Mr. Garey, the president of the United States Steel Corporation, that in a few weeks' time a beginning would be made in the reduction of the length of the working day in American steel mills from twelve hours to eight hours. The change will be effected gradually, and it is not yet known what is the number of the workers affected by it. It is probable, however, that an advance in the prices of steel products will be necessitated by the reduction in the number of hours worked.

On Thursday, the 12th inst., the conference of the Miners' Federation at Folkestone passed a resolution to the effect that no vote should be taken upon the question of terminating or continuing the national wage agreement, but that the executive committee should be empowered to submit suggestions to the National Wages Board for the improvement of certain clauses of the agreement and to report to a later Conference. The proposed alterations related to the revision of the rates of profits and wages so as to improve the wages position of the men, the revision of the present minimum in the agreement, and the provision of fuller information as to costs.

At the concluding session of the Conference on Friday, the 13th inst., one of the resolutions passed proposed the continuation of the present levy of 1*d.* per ton on coal for the provision of miners' pensions. Another resolution was to the effect that the executive should press for the compulsory use of safety appliances for the reduction of cage and other mine accidents. Four resolutions in favour of a statutory six-hour day were considered in committee, but were referred to the executive committee without any definite action being taken. A further resolution, the object of which was to make membership of the Miners' Federation one of the conditions of employment in and about the mines, was carried by a large majority. Mr. Herbert Smith was re-elected president of the Federation, with Mr. Stephen Walsh, M.P., as vice-president, and Mr. W. Richardson as treasurer.

There are still no signs of an agreement in the dispute with the boilermakers in the shipbuilding industry, and while some of the men are desirous of returning to work, a strong section opposes settlement on the terms of the overtime and night-shift agreement. It is stated that the votes of the Tyneside branch showed a majority of six to one against acceptance. The employers, quite rightly it appears to us, have no intention of modifying their demand for the honouring of the agreement by the boilermakers, since to do so would involve a breach of faith with other trades. The dispute has now been in progress for over ten weeks and its effect has been, of course, to cause still further dislocation of the industry, which was already in a depressed condition. We understand that Mr. John Hill, the general secretary, and other representatives of the Boilermakers' Society, had an interview with the Minister of Labour, Sir Montagu Barlow, at the House of Commons on Tuesday last and submitted their case for a court of inquiry into the circumstances resulting in the lock-out, while representatives of the Shipbuilding Employers' Federation met Sir Montagu, at his request, on the following day. The representations made by both parties are now under consideration and a decision will be announced in due course.

At the time of writing there appears to be no immediate prospects of a general settlement of the dock labourers' strike, which continues in spite of the advice of the trade union leaders to the men to return to work. A long conference between the leaders of the Transport and General Workers' Union and delegations of men from the affected ports, however, was held at the Central Hall, Westminster, on Wednesday last, but the nature of the proceedings has not been made public up to the time of going to press. The strike, it will be remembered, originated in Hull, where the men refused to accept a reduction in wages agreed to by the employers and the union officials, as well as by the delegates of the rank and file. Dock labourers at London, Manchester, the Bristol Channel ports, Grimsby and other parts of the country followed the lead of the Hull men, but, so far, attempts to extend the strike to other transport workers have been attended by no great measure of success, although the meat porters at Smithfield Market, London, have

joined the dockers, and some road transport men have left work. A brief strike of porters at Covent Garden Market also took place on Tuesday last.

Of those ports at which the strike has been effective, work has been resumed at the Bristol Channel ports and at Grimsby, but work at the London, Hull and Manchester docks is at a standstill, and the effect of this upon our overseas trade, which was showing some signs of improvement, will be particularly serious. The employers appear to be awaiting the outcome of the struggle with patience, and have decided, for the present, to inhibit the unloading of foreign vessels by their crews in order to avoid the aggravation which might arise from this cause. Numerous perishable cargoes are, however, spoiling in the docks, and vast quantities of shipping are held up, a condition of affairs which cannot be tolerated for long.

The union officials appear to be quite unable to handle the situation arising out of the strike, which seems to us very largely to nullify the whole principle of collective bargaining upon which trade unionism is based. Actually the strike appears to be more of a political than of an economic character and *The Times* ascribes it mainly to the Communist organisations which are as desirous of discrediting orthodox trade union leadership as they are of overthrowing capitalism. Whatever the cause of the present situation may be, no effort should be spared by those who have the best interests of the workers at heart to discover and remove it, since industrial disturbances of this character are no less injurious to labour as a whole than they are to the rest of the community.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—Striking increases are recorded in the official returns for June. The total quantity received at Hull from the South Yorkshire district during the month, 645,122 tons, represented an increase of 266,289 tons, compared with the corresponding month last year. For the six months January to June the total was 3,546,713 tons, compared with 2,163,594 tons in the first half of last year. On the month export trade doubled, reaching a total of 319,379 tons, an increase of 168,009 tons, compared with June last year. The total exports for the past six months increased by 1,182,294 tons. Germany took nearly half the total exported last month, 152,554 tons, the next largest buyers being France 44,146 tons, Sweden 25,943 tons, Holland 25,730 tons, and North Russia 13,303 tons. Some very big outputs were recorded at individual collieries. The Brodsworth, Bullcroft, Hickleton, Ramcroft and Yorkshire Main group sent 104,732 tons, compared with 65,000 tons in June, 1922. Aldwarke Main doubled its output sent to Hull compared with June of last year, and big increases were also shown in the case of Manvers Main and Rother Vale.

Iron and Steel.—In raw and semi-finished materials the market is uniformly sluggish. Mid-summer holidays and the completion of stock-taking operations are having the usual adverse effect on business. Buying of basic iron and steel is limited to necessary tonnages to cover immediate commitments, though if producers of forge and foundry iron continue to be faced with the difficulty experienced during the past few weeks in finding an outlet for their manufactures on contract account, it is likely that several furnaces will have to be closed down. The question of the current cost of coke is also entering largely into consideration. Export demands are again on the rise, and whereas overseas buyers are willing to pay as much as 40*s.* per ton for blast-furnace qualities f.o.b., home contractors will not go beyond 26*s.* per ton at the ovens, which represents a considerable decrease on the contract prices prevailing for the first six months of the year. The current demand for soft basic steel, though diminished as compared with that of the earlier months of the year, is sufficient to have warranted the lighting up of more than half of the furnaces in the Sheffield district. A few orders for strictly limited tonnages of crucible steel have come to hand from the Continent. High-speed steel is on order for cutting tools, and alloy steels are going into consumption in the automobile industries. More orders have been booked for locomotives and rolling stock, in which Sheffield and district engineering concerns will benefit. India and South Africa are buyers of wagons. There is a fair volume of movement in electrical equipment and colliery appliances. Business in tools is very erratic. While a few firms are working overtime, they form the exception rather than the rule. Substantial contracts for files have been booked for the British Admiralty. Cutters are on order for the docks at Portsmouth and Devonport, and a considerable quantity of hand tools is to be supplied to the Egyptian State Railways.

South Yorkshire Coal Trade.—The usual mid-summer reductions in house coal and certain classes of manufacturing fuels are beginning to take effect. Barnsley best Silkstone have this week been reduced 1*s.* 9*d.*, Derbyshire best brights 6*d.*, and Derbyshire best house coal 9*d.* Renewed weakness in nuts has induced collieries to offer supplies at 2*s.* 6*d.* per ton less than the rates ruling last week. Slacks, despite a fairly strong demand, have also been marked down an average of 6*d.* to 1*s.* Current business is confined almost solely to contract deliveries. There is scarcely anything doing in the open market. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 26*s.* 6*d.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 20*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 16*s.* to 18*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Transactions in Cleveland pig-iron are few and small, and traders now speak anything but hopefully of the future. No. 1 is still extremely scarce with the result that its value is maintained at 115*s.*, but other qualities are in more than ample supply and are weak in price. Makers ask 107*s.* 6*d.* for No. 3 g.m.b., but below that figure has been accepted. Foundry 4 is quite a drug on the market and is offered freely at 100*s.* and even less. There is not a great deal of forge kind available for the open market, and the price is put at 97*s.* 6*d.* All the foregoing quotations are f.o.t. makers works, or f.o.b. Tees.

Hematite.—Supply of East Coast hematite is considerably in excess of needs, and makers are rather keen sellers, though they declare that rather than further lower prices they will damp down furnaces unless working expenses are unexpectedly reduced. Nos. 1, 2 and 3 are quoted 105*s.* both for home use and for shipment overseas, and No. 1 is put at a premium of a shilling.

Foreign Ore.—There is little or nothing doing in imported ore, and the quotation of 24*s.* c.i.f. Tees for best rubio is purely nominal.

Ironstone Miners' Wages.—The Cleveland Ironstone mine owners, and miners' representatives, have this week reached an agreement by which the men's wages will be increased from the 23rd inst. by 14 per cent., raising wages from 88½ per cent. above the standard to 102½ per cent. above the standard.

Manufactured Iron and Steel.—Practically all descriptions of finished iron and steel are slow of sale, orders on hand are being run off rather rapidly, and values show further marked downward tendency. Indeed, the situation generally is more gloomy and discouraging than for a long time past. The anticipated reduction of 10*s.* in steel billets is announced, and manufacturers of other materials are prepared to favourably consider any reasonable offers. For home business the following are among the recognised market quotations:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.* 10*s.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles, 9*l.* 10*s.*; steel joists, 9*l.* 10*s.* to 9*l.* 15*s.*; heavy steel rails, 10*l.*; fish plates, 14*l.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 18*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Another anthracite colliery deal has just been concluded in South Wales. The Great Mountain Collieries Company, Limited, Llanelly, has acquired the undertakings of the Ammanford Colliery Company, Limited, consisting of the Ammanford Little Vein, the Ammanford Red Vein, the Pontyberem Clynebog Collieries and the Pontyberem Slant. The Ammanford and Pontyberem Collieries are among the most important in the anthracite district and the purchase price is understood to be about 300,000*l.* It is also announced that the Dulais Anthracite Collieries have been sold to Messrs. Hull, Blyth and Co., Limited, depot proprietors. The volume and value of the South Wales coal export trade in June showed a falling-off when compared with May, which was the best month of the year. In all, 2,550,231 tons of coal, valued at 3,618,626*l.*, were shipped abroad from the principal ports, which represented a reduction of 207,352 tons and of 295,053*l.* when compared with May. The average f.o.b. price of all the coal shipped at 28*s.* 4*d.* per ton was the same as in May, though the average for steam large at 30*s.* 5*d.* showed a reduction of 5*d.*, and steam smalls at 22*s.* 6*d.*, a drop of 4*d.* Anthracite large, however, at 40*s.* 8*d.*, represented an increase of 8*d.* and small at 22*s.* an advance of 3*d.* In respect to steam coals, small shipped from Cardiff averaged 22*s.* 10*d.* in June, compared with 23*s.* in May, through 27*s.* 6*d.* against 27*s.* 10*d.*, and large 31*s.* 3*d.* against 31*s.* 4*d.* Small steams exported from Swansea averaged 20*s.* 9*d.* compared with 20*s.* 10*d.*, through 21*s.* 11*d.* against 22*s.* 2*d.*, and large 28*s.* 11*d.*, the same as in May. The general position of the coal market shows no decided change. Inquiries are fairly numerous and a fair amount of buying is going on. Business, however, is of a hand-to-mouth character with prices irregular, and dependent on individual circumstances. The best grades of Admiralty large coal are steady on the basis of 31*s.* to 32*s.*, but other qualities are freely offered. Best Monmouthshire large is obtainable at 28*s.* 6*d.* and ordinary sorts down to 25*s.* Smalls are also in ample supply, with the best steam qualities from 23*s.* to 24*s.* and inferiors down to 14*s.* There is an improved inquiry for coke, and the export price of foundry has been raised from 45*s.*–55*s.* to 55*s.*–60*s.* Patent fuel, however, is not in much demand, and sellers are ready to accept from 33*s.* to 35*s.*, according to quality.

Iron and Steel.—Exports of iron and steel goods last week were the smallest in volume for a month. Shipments of tin-plates and terne plates amounted to only 6,750 tons, compared with 9,380 tons in the previous week, black plates and sheets to 4 478 tons against 3,785 tons, galvanised sheets to 2,202 tons against 5,580 tons, and other iron and steel goods to 6,017 tons against 7,279 tons.

Canadian Cattle.—Another steamer—the Canadian Victor—is due to arrive at Cardiff to-morrow with 229 head of cattle shipped direct from Canada. This is the second consignment shipped in seventeen years. All the beasts brought over by the Canadian Leader, a fortnight ago, have been sold and reports indicate that the quality of the meat was extra good.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel and Iron Trades.—There is nothing doing at present in the steel and iron trades of the West of Scotland as all the establishments are now closed down for the annual holidays. The finishing up was devoid of any excitement owing to the recent slackness of general trade, and at few works was there any sign of the least pressure for deliveries. The commercial sides do not report any expansion in business this week yet and it is feared that few fresh contracts will be secured until quotations are shaded a bit. Buyers are building on getting reductions, being of opinion that producers will be inclined to meet them in order to get a decent tonnage booked to maintain the running of their works. Inquiries are not very plentiful at the moment, but a little inducement might bring out something worth getting. Repairs to furnaces and mills are now general and many of the establishments will not be re-opened until the end of the month. The black steel sheet makers have had a fair run for a while, but business has slackened off recently, and as in other branches of industry the outlook is not too bright. Shipbuilding material is almost a dead letter in the meantime, and until a settlement of the boilermakers' dispute is reached the prospect of any demand from the shipyards is likely to be very poor. The current prices are as follow:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; sheets, ¼ in. to ½ in., 12*l.* 10*s.* per ton; and "Crown" bars, 12*l.* per ton, all delivered Glasgow stations

Scottish Pig-iron Trade.—Business in the Scottish pig-iron trade has been showing a falling-off during the latter part of the past half-year period and contracts have recently become very scarce. Quite a big trade was done with overseas markets for a considerable time, but the demands have not been so good of late, and although some fair inquiries have been going around during the past few weeks the tonnage secured is not very heavy. The furnaces are now closed down for holidays, and bookings, to commence when they are rekindled, are not very numerous. The demand for hematite iron is not expected to be large, but furnace qualities are likely to be in better request. The following are the current quotations:—Hematite, 5*l.* 17*s.* 6*d.* per ton, delivered at the steel works; No. 1 foundry iron, 5*l.* 12*s.* 6*d.* per ton, and No. 3, 5*l.* 7*s.* 6*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, July 14, amounted to 258 tons. Of that total 198 tons went foreign and 60 tons coastwise. For the corresponding week of last year the figures were 1,039 tons foreign, and 81 tons coastwise, making a total shipment of 1,120 tons.

THE BRITISH ENGINEERING STANDARDS ASSOCIATION. At the annual general meeting of the Association, held on the 12th instant, the chairman, Sir Archibald Denny, Bart., in reviewing the year's work, mentioned that the Association was faced with a deficit of about £1,700. He expressed the hope that the Government, and the industry as a whole, would assist in putting the finances of the Association on a more stable basis. He added that the continually increasing quantity of work with which the Association had to deal necessitated more generous financial support than was now received, remarking that neither the Government nor our industries as a whole appeared to appreciate fully the value to the home and export trade of the country of the voluntary labours of some 2,000 engineers who formed the Association.

THE ROYAL NATIONAL LIFEBOAT INSTITUTION.—On Thursday next, the 26th instant, the inaugural ceremony of the new motor lifeboat H. F. Bailey will take place at Cromer, Norfolk. The boat has been provided by the Royal National Lifeboat Institution from a legacy left by a London merchant whose name the boat bears, but the interesting feature of the installation is the fact that the boat house and slipway are placed at the end of the pier so that the boat can be launched into deep water at any state of the tide. Many of the difficulties and dangers which attend the launching of a heavy boat from the beach in bad weather are thus avoided. Another point of interest in connection with the work of the Institution will be the completion early in August of a new and exceptionally powerful type of motor lifeboat which will be stationed at New Brighton on the Mersey. The boat, which will be 60 ft. in length and will be equipped with two 90 h.p. engines, is now under construction at Cowes, and when completed will proceed to her station *via* the East coast and the North of Scotland, calling at about 30 different seaports *en route*. Interested parties resident at practically any part of the Coast will thus have an opportunity of inspecting the vessel, which, we understand, will be the most powerful motor lifeboat in the world.

20-TON REVOLVING WHARF CRANE AT VERNON-ON-SHORE.

CONSTRUCTED BY MESSRS. THOMAS SMITH AND SONS (RODLEY), LIMITED, ENGINEERS, LEEDS.

(*For Description, see page* 79.)

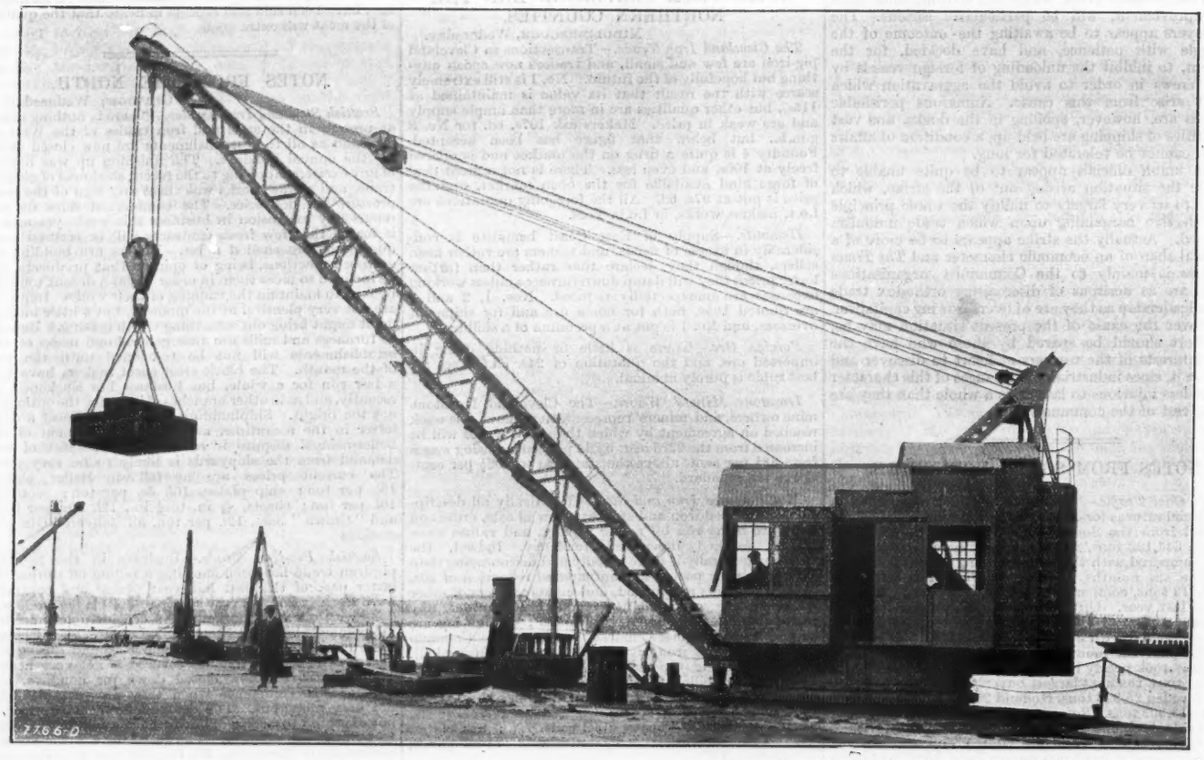


FIG. 5.

Fig. 6.

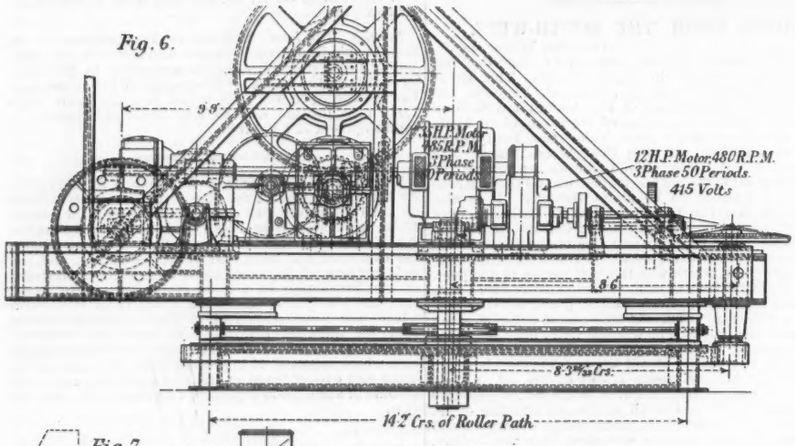


Fig. 7.

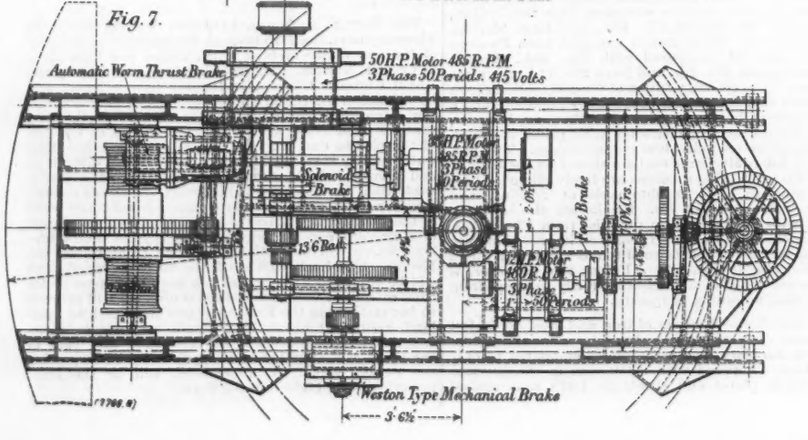

Automatic Worm Thrust Brake
50 H.P. Motor 485 R.P.M. 3 Phase 50 Periods. 415 Volts
35 H.P. Motor 485 R.P.M. 3 Phase 50 Periods
Solenoid Brake
Foot Brake
13'6" Rail
Weston Type Mechanical Brake
3'6½"

Fig. 8.

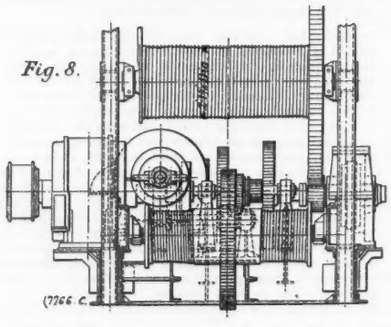
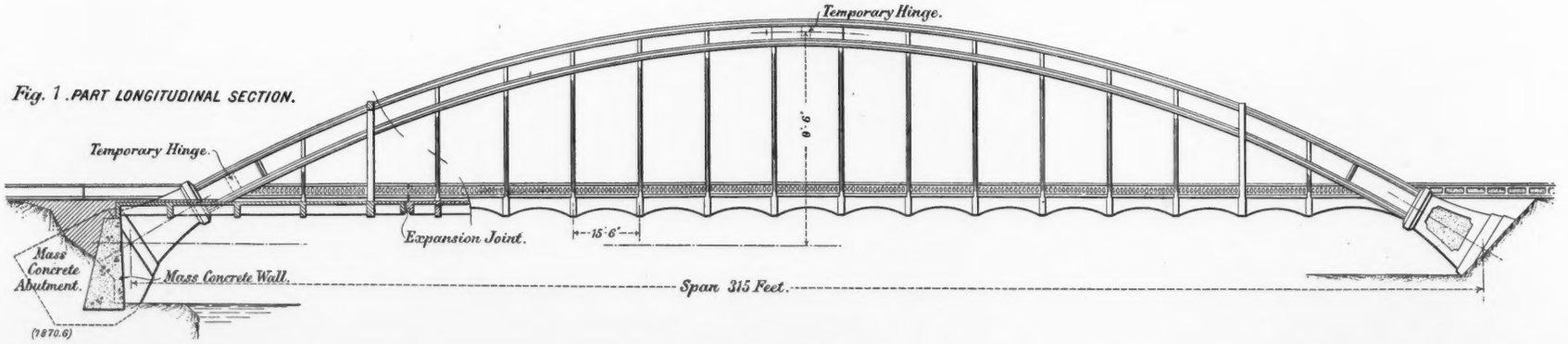


TABLE OF PARTICULARS.

Lift at 30 ft. radius	20 tons.
Lift at 50 ft. radius	10 tons.
Lifting speed, 20 tons	20 ft. per min.
Lifting speed, 10 tons	40 ft. per min.
Derricking (50 ft. to 30 ft.) ...	1¼ min.
Slewing (complete revolution)...	1½ min.
Lifting motor	50 b.h.p.
Derricking motor	35 b.h.p.
Slewing motor	12 b.h.p.

REINFORCED CONCRETE BRIDGE OVER THE VESUBIE RIVER.

(*For Description, see Page* 70.)



ELEVATION.

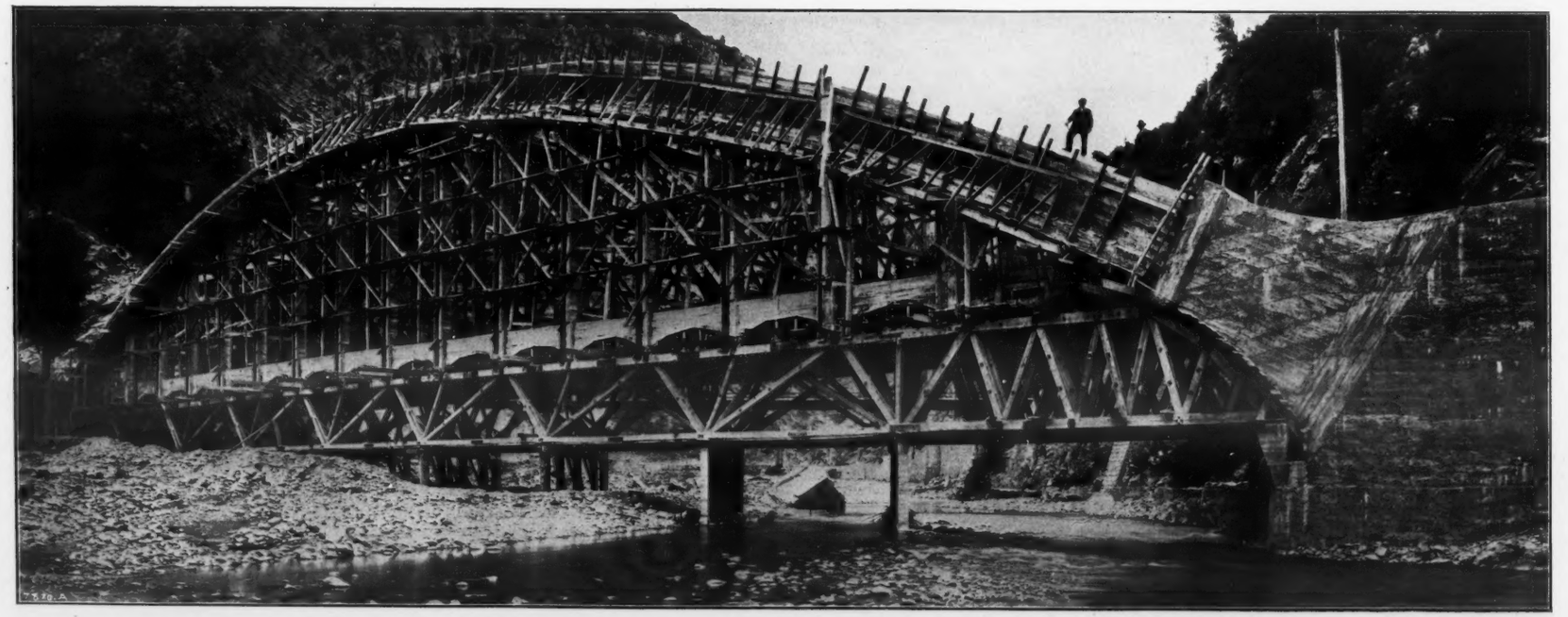


FIG. 2. VIEW SHOWING TEMPORARY STAGING AND SHUTTERING.

REINFORCED CONCRETE BRIDGE OVER THE VESUBIE RIVER.

(*For Description, see Page 70.*)

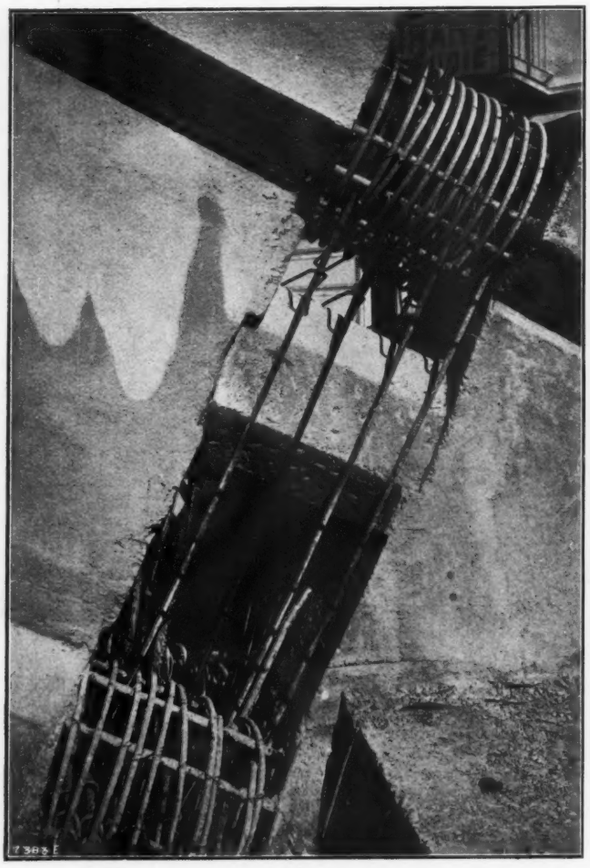


FIG. 3. TEMPORARY HINGE AT SPRINGING UNDER LOAD.

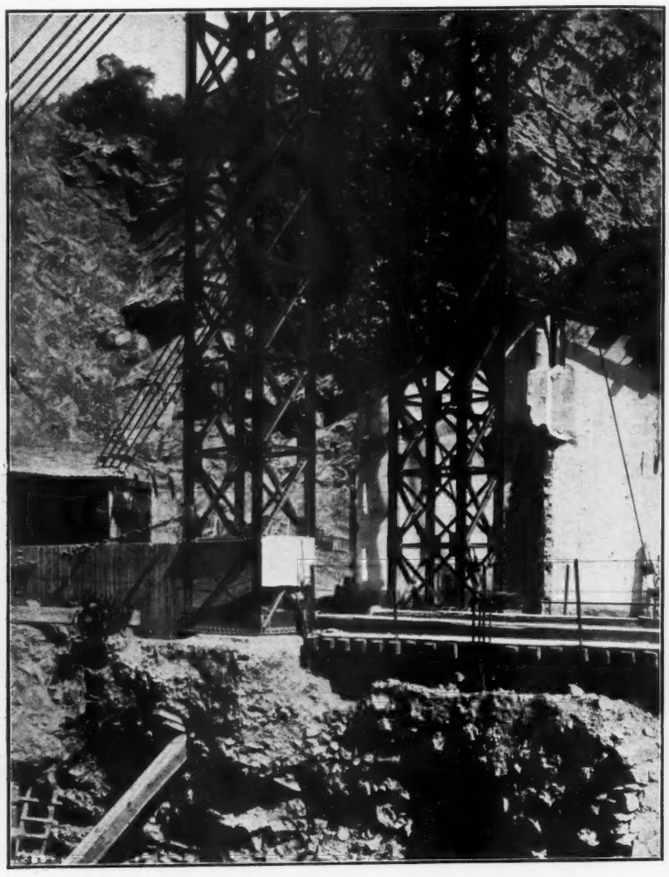


FIG. 4. METHOD OF SUPPORTING TOWER OF TEMPORARY SUSPENSION BRIDGE.

Fig. 5. SECTION AT SPRINGING.

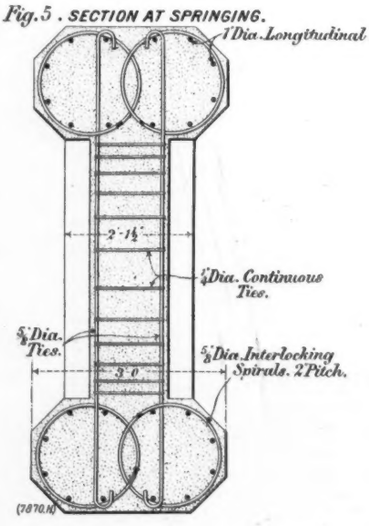


Fig. 6. SECTION AT CROWN.

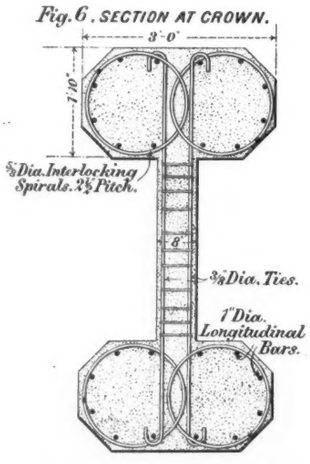


Fig. 7. PART PLAN OF DECK SHOWING EXPANSION JOINT.

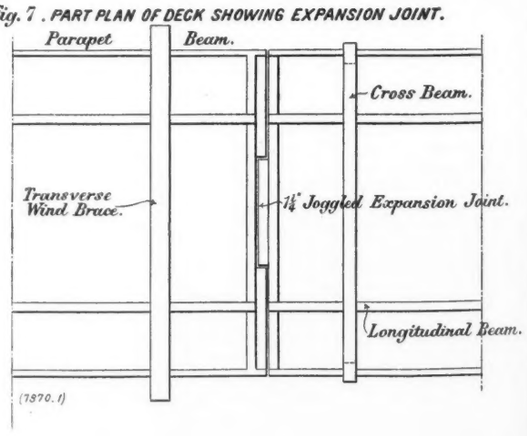
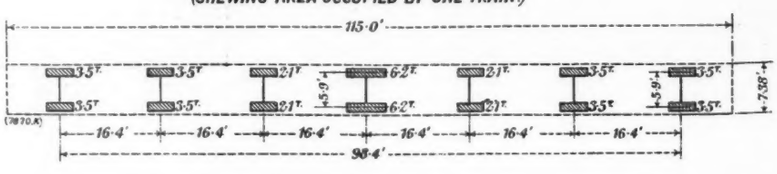


Fig. 8. STANDARD TRAIN OF LOADS.
(SHEWING AREA OCCUPIED BY ONE TRAIN.)



REINFORCED CONCRETE BRIDGE OVER THE VESUBIE RIVER.

(*For Description, see Page 70.*)

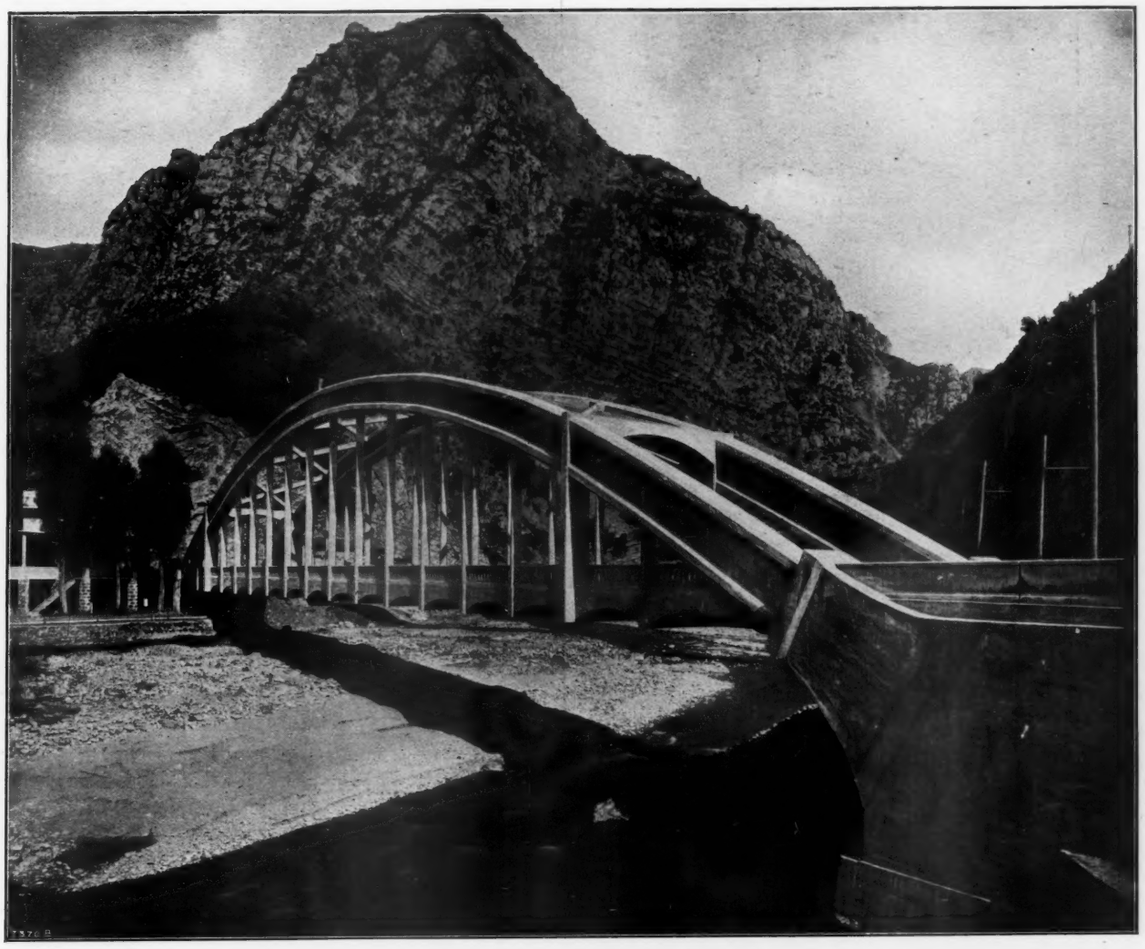


FIG. 9. THE COMPLETED BRIDGE.

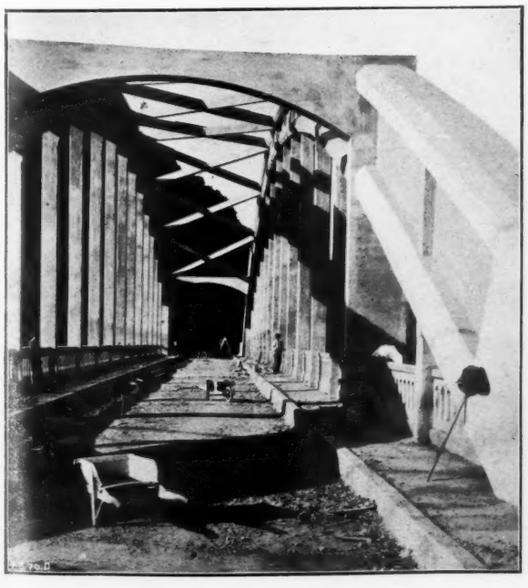


FIG. 10. END VIEW SHOWING WIND BRACING.

FIG. 11. TEMPORARY STAGING AND CONCRETE SHEET PILING.

THE HYDRO-ELECTRIC SUPPLY TO COLWYN BAY, NORTH WALES.

(For Description, see Page 71.)

FIG. 4. 6,600-VOLT SWITCHGEAR: BRON-Y-NANT STEP-DOWN TRANSFORMER STATION.

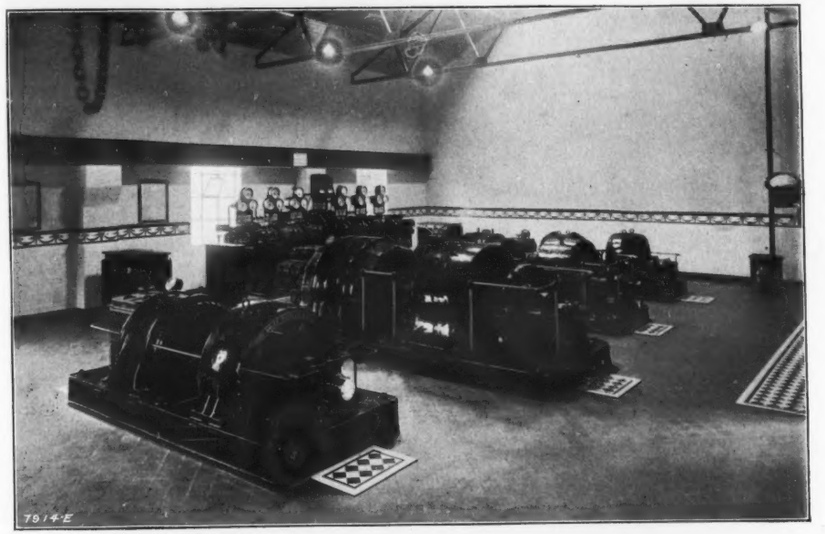


FIG. 5. INTERIOR OF IVY STREET CONVERTER SUBSTATION.

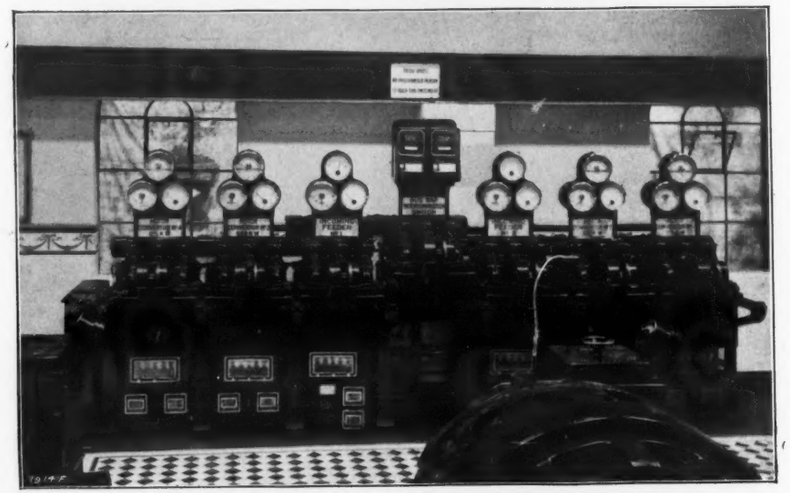


FIG. 6. 6,600-VOLT SWITCHGEAR: IVY STREET CONVERTER SUBSTATION.

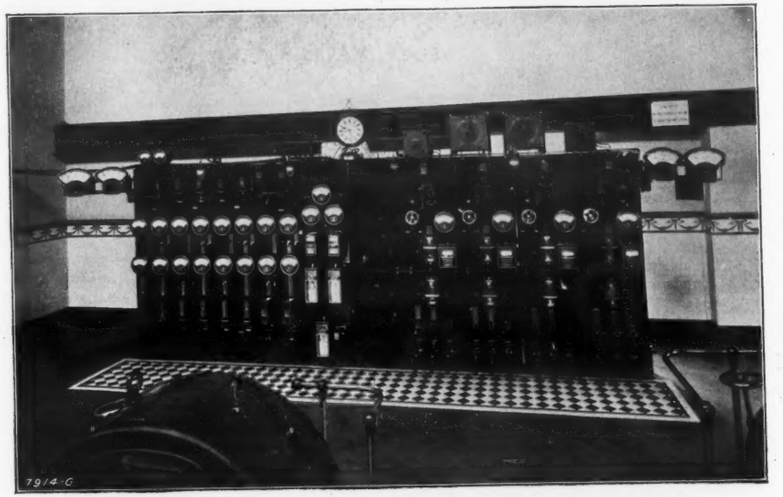


FIG. 7. LOW-TENSION DIRECT CURRENT SWITCHBOARD: IVY STREET CONVERTER SUBSTATION.

(To face page 71.)

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Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

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CONTENTS.

	PAGE
The Laws of Heat Transfer (*Illus.*)	69
Reinforced Concrete Bridge over the River Vesubie (*Illus.*)	70
The Hydro-Electric Supply to Colwyn Bay (*Illus.*)	71
The International Navigation Congress (*Illus.*)	73
20-Ton Revolving Wharf Crane at Vernon-on-Shore (*Illus.*)	79
Oil-Immersed Star-Delta Motor Starter (*Illus.*)	80
Frequency Curve of British Power Stations (*Illus.*)	82
Industrial Notes	82
Notes from South Yorkshire	83
Notes from Cleveland and the Northern Counties	83
Notes from the North	83
Notes from the South-West	83
The Size and Load-Factor of British Power Stations	85
Reflections on the Royal Show at Newcastle	86
The World's Merchant Shipping	86
The Progress of Aviation	87
The Economic Situation of Norway	87
The Fatigue Limit and Proportionality on Monel Metals (*Illus.*)	88
The Conversazione of the Institution of Civil Engineers	88
Notes	89
Literature	89
Books Received	92
Hydraulic Machine for Laminated Spring Buckles (*Illus.*)	92
The National Physical Laboratory	93
Clyde Marine Oil Engines (*Illus.*)	95
Catalogues	98
ENGINEERING Patent Record (*Illus.*)	99

Three One-Page Plates.—REINFORCED CONCRETE BRIDGE OVER THE VESUBIE RIVER.

One One-Page Plate. — THE HYDRO-ELECTRIC SUPPLY TO COLWYN BAY, NORTH WALES.

ENGINEERING.

FRIDAY, JULY 20, 1923.

THE SIZE AND LOAD-FACTOR OF BRITISH POWER STATIONS.

So much attention is paid to the equipment and performance of the larger power stations that a casual reader of technical literature might gather the impression that such plants are typical of the central station industry in this country. Even those who are directly concerned with power station practice perhaps hardly realise how far such a view is from accordance with facts, for most discussions of power station matters turn on the problems peculiar to the larger plants. Any generating unit rated at less than 5,000 kw. is now-a-days regarded as quite a small machine, so that a statement that more than half the electricity undertakings in this country have each a total plant capacity of less than that of one such unit might seem surprising. Still more strange might it be to hear that more than a quarter of the public power stations in Great Britain have each less than 1,000 kw. of plant installed. Nevertheless we believe these statements to be true, and they certainly give much food for thought. Some small stations are extremely efficient, and a large proportion of them are as well or better managed than some of the more imposing undertakings. The keenness of their engineers and the personal attention to details, which their smallness renders possible, go far to offset the limitations which smallness imposes, yet other things being equal, the large station must always beat the small one where cheapness of production is concerned.

This view which, besides being justified by the inherently greater efficiency of the equipment of large stations, is corroborated by the figures given in the recently published report of the Electricity Commission, does not necessarily imply that it would be advisable to close down all the smaller stations as soon as possible and transfer their loads to super-stations. The transmission of electricity is expensive, not only in the form of line and transformer losses, but in the capital expenditure and maintenance charges of the transmission system. In very many cases it is cheaper on the whole to supply electricity from a small and relatively uneconomical station situated in the centre of an isolated load area, than it would be to import the supply from a more efficient station a considerable distance away, particularly as the imported supply would have to bear the cost of the interest and sinking fund charges on the capital spent in the original local undertaking. Hence the day of the small station is by no means over, but it is equally certain that we have at the present time far too many of them. Those situated in areas capable of development, and judging by Canadian and American figures of electricity consumption there must be very many such areas, ought to grow rapidly into the class of large stations, providing that they are suitably located with regard to condensing water and fuel supplies. Others, without such facilities, should be closed down and their loads carried by stations more fortunately situated. By these means the average size of British stations could be noticeably increased, with a consequent increase in the cheapness of electricity supply.

The policy of the Electricity Commissioners is to encourage development of electricity supply along the lines indicated undeterred by considerations of local politics or parochial jealousies, and every one will wish them well in their task. However proud some local council may be of its power station, if it is located where condensing water is inadequate or where fuel cannot be economically delivered, no extension should be permitted if any alternative preferable from an engineering point of view is available, and the station should be put on the list as one for extermination as soon as possible. One aspect of the situation with which the Commissioners are faced in their endeavours to co-ordinate and cheapen the electricity supply of this country, namely the extraordinary number of small stations which exist, is shown by the facts stated below. We should have liked to present them graphically in the form of a curve, but the extremes are so wide that no diagram of practical size will include them.

There are, according to the Commissioners' last report 536 power stations in this country belonging to "authorised undertakers." Of these 396 are steam stations, 60 are driven by producer gas, 52 use oil fuel and 28 derive their power from waste heat, destructors, town gas or waterfalls. No station generating less than 25,000,000 kw.h. per annum can possibly be called large, in any modern sense of the word, and yet only 44 plants in the country exceed even this moderate output, and of these only 9 exceed an output of 100,000,000 kw.-h. We have, on the other hand, as many as 359 stations, of which 236 are steam-driven stations, with an output of less than 5,000,000 kw.-h. per annum, or less than would be produced by a single 2,000-kw. machine running 30 per cent. of the time. Stations coming into this class are tiny little affairs, and the average coal consumption even of the best of them is two or three times the figure obtained in large plants. The fact that there are 236 of them in existence, not counting those driven by gas or oil engines, with an average coal consumption of 6·47 lb. of coal per kilowatt-hour, whereas 2·40 lb. is sufficient for any plant with an output of 100,000,000 kw.-h., shows what savings are to be expected with increase of size. The average coal consumption of the 18 steam-driven stations having an output between 50,000 kw.-h. and 100,000 kw.-h. per annum is no less than 20·90 lb. per kilowatt-hour, and the best thermal efficiency obtained in any one of these stations is 4·10 per cent., as against 17·20 per cent. for a station in the largest class.

Besides increasing the average size of power stations in this country by developing or eliminating many of the small ones, there is another matter which is very important in effecting a reduction in power costs, and that is the improvement of the load factor. As we have pointed out on other occasions, there is no reason to believe that in a station with a given annual output, the coal consumption will be decreased by an improvement in the load factor. In practice, however, the increase of the load factor of a given station involves an increase in output with all the benefits following

therefrom. Furthermore, quite apart from questions of operating economy, a high load factor means a large output for a small capital expenditure, and the interest charges per kilowatt-hour sold are therefore less, so that the supply is cheapened on this account. For many years past, our contemporary the *Electrical Times* has published periodical tables of power-station statistics of much interest to engineers, and from a recent copy of these tables we have taken the data from which the diagram on page 82 has been prepared. This diagram shows in a graphic manner the kind of load-factors which are found in British power stations. The figures refer to 277 stations only, but it may safely be presumed that the stations omitted are insignificant ones, whose figures, even if included would not tend to alter the general trend of the curve.

The load-factor, which is defined as the ratio of the average load to the maximum during the year, will be seen to vary between 8 per cent. and 34 per cent., these being the extreme figures. The vast majority of the stations fall between 11 per cent. and 26 per cent., 17 per cent. being the most fashionable figure. It cannot be said that this is at all a satisfactory state of affairs. If electricity were used in this country with the same freedom as abroad a load factor of about 30 per cent. should be possible in a very large number of our towns, and there is no reason why 50 per cent. or 60 per cent. should not be obtainable in certain areas. We have commented before on the fact that Shanghai has developed a load factor of more than 50 per cent., and an output greater than that of any municipal undertaking in Great Britain, and when this is possible it seems extraordinary that industrial areas in this densely populated and comparatively wealthy country should not yield load factors of the same order if properly cultivated. High load factors, large outputs and cheapness of supply are all intimately connected, and any improvement in one of them will react on the others and make further economies possible. Electricity will be cheaper when it is more plentifully used, and it will be more plentifully used when it is cheaper, but neither of these advantages will be conferred on the public until an effective dissatisfaction is shown with the present state of affairs.

REFLECTIONS ON THE ROYAL SHOW AT NEWCASTLE.

FARMING is an industry which changes slowly, and it follows that there is always a great similarity between the machinery exhibits at the successive annual shows of the Royal Agricultural Society. The importance and the representative character of these shows, however, render them the best means of noting such developments as are being attempted or are taking place in the agricultural machinery industry. A few years ago the predominant feature was the number and variety of the agricultural tractors to be seen, and the only question appeared to be which type of machine would ultimately prove most generally useful. Matters are very different to-day. The tractors which were going to save the British farming industry have not done so and, indeed, are themselves hard put to it to survive. There were plenty to be found at the Newcastle show, but little or no interest seemed to be taken in them, and the general impression appeared to be that the day of the tractor had passed, at any rate for the present. Experience has shown that these machines require more skilled attention than they can get on the average farm to keep them in working order, and the reduction in the value of horses and of labour has made their advantages less important. Mechanical methods of ploughing and cultivation are, however, almost certain ultimately to prevail, but for the time being the tractor is under a cloud.

The portable steam engine, which for so long was the standard source of motive power for threshing, chaff-cutting, grinding, &c., on farms, seemed during the past few years to be doomed to extinction by the competition of the tractor and the portable oil engine. Last year, we believe, there was only one engine of this type on exhibition in the whole of the Royal Show, but this year at Newcastle at least four were to be seen. This may indicate a certain revival of interest in the portable steam engine, but the portable oil engine is an extremely strong competitor, no less than ten firms showing engines of this kind. Portable producer-gas plants and engines were shown by three different makers but only in small sizes, the producers being of the suction type using charcoal as fuel.

The small electric-lighting plants, consisting of a petrol or paraffin engine driving a dynamo with an output of 1 kw. or 2 kw. were innumerable, while the possibility of the use of electricity on a larger scale in connection with farming operations was considered by some exhibitors. Mr. R. Borlase Matthews who is well known as an enthusiastic advocate of electrical methods on the farm looks forward to the day when the agriculturalist will be able to obtain his power for ploughing or driving fixed machinery by tapping overhead electric transmission lines, and he exhibited apparatus for doing this and utilising the electricity so obtained. Overhead transmission lines are, however, not likely to become available for farmers in this country until the absurd regulation which requires the conductors to be put underground when crossing roads, is cancelled. Such lines are not nearly so intrinsically dangerous as is a live trolley wire suspended above a crowded street, and the risks due to the latter are considered negligible.

A special feature of the Royal Show this year was the large number of exhibits connected with road-making. No fewer than 10 firms showed road rollers, all the well-known makers being represented and one or two new comers into the field. The steam roller still holds its own against the motor roller, but the latter now competes even in the heaviest classes, thanks largely to the energy with which Messrs. Barford and Perkins have developed the type. Stone-breakers, tar boilers, road sweepers, tar-macadam mixers and other machinery and apparatus all testified to the interest now being taken in the construction of roads. All of this machinery was built on more or less established lines, the most novel being perhaps the tamping machine of Messrs. B. Johnson and Son, of Ilkley, which will rapidly consolidate a road after trenches have been refilled, or other repairs effected.

The necessity for good roads was emphasised by the display of the kind of vehicles which they have to carry in ever-increasing numbers. Twelve firms showed steam traction engines, large or small. Steam lorries were too numerous to mention. The six-wheeled steam vehicle was prominent on the stands both of Messrs. Robey and Co., Limited, and the Sentinel Wagon Works, Limited. In both instances the carrying capacity was 10 tons at a legal speed of 12 m.p.h., the platform area being about legal speed of 12 m.p.h., the platform area being about 24 ft. by 7 ft. Machines like these are putting quite a new aspect upon the question of the transport of goods by road, for their capacity is equal to that of the majority of the little trucks still used on our railways, and though their running speed may be less, their ability to carry goods from door to door without loading or unloading on route usually allows of quicker delivery than the railways can accomplish. They are essentially suited to the inter-urban work of the road transport companies or the large manufacturers, but for the community to gain the full advantage of their existence roads will have to be provided suitable to their requirements. The weights on the axles of the Sentinel wagon, when fully loaded, are 4·5 tons, 8 tons and 6·5 tons, and the unloaded weight of the whole vehicle rather more than 9 tons. Rubber tyres are, of course, used by both makers.

There appeared to be no particularly noteworthy development of any agricultural implements shown at Newcastle. Ploughing, cultivating, reaping and threshing machinery seems to have long ago reached its limits except for very minor improvements, such as ball-bearings for high-speed shafting, &c. The most important labour-saving device for the farmer, which we noticed was the stack-feeder of Messrs. William Foster and Co., Limited, of Lincoln. This apparatus entirely eliminates the need for any men on the thresher, either to cut the bands or feed the sheaves to the drum. Two men are thus saved, the work of the men on the rick is lightened, and the rate of threshing is considerably increased. We have become so used to look abroad for labour-saving devices in connection with agriculture that it is satisfactory to see that our Lincoln firms are not behindhand in originating new developments. We have referred more fully elsewhere to the Foster stack feeder as its mechanical features are of considerable interest. It may be mentioned that it was at Messrs. Foster's works that the military "tanks" were first constructed.

THE WORLD'S MERCHANT SHIPPING.

To a nation dependent as we are upon overseas trade for our existence, it is a matter of interest and importance to consider, from time to time, the position of our shipping industry and to compare it with those of the other maritime nations of the world. Convenient and reliable data for making such comparisons are provided in the statistical tables issued in each yearly volume of the Register Book compiled by Lloyd's Register of Shipping, and from the current edition, which has just made its appearance, we find that the merchant navies of the whole world now include 33,507 vessels with an aggregate tonnage of 65,166,238. It also appears that while the latter figure has increased by nearly 33 per cent. since June, 1914, when it was 49,089,552 tons, the tonnage owned in Great Britain and Ireland alone has only increased from 19,256,766 tons to 19,281,549 tons, the difference of less than 25,000 tons being practically negligible.

The foregoing figures include vessels of all types exceeding 100 gross tons each, but if we consider only sea-going steamers and motor vessels of steel or iron construction, as being the class of shipping of most economic importance, we find that the world's total tonnage has increased in the same period, and in round figures, from 42,514,000 tons to 57,939,000 tons, the difference of 15,425,000 tons representing an increase of 36 per cent. Of this class of shipping, 19,077,000 tons are now owned in Great Britain and Ireland as compared with 18,877,000 tons in June, 1914, the difference of 200,000 tons being an increase of but little over 1 per cent. Most other nations, on the other hand, have made important additions to their mercantile fleets during the period, the most important case being that of the United States, which country now owns 12,416,000 tons of sea-going steel and iron steamers and motor ships, as compared with 1,837,000 tons in June, 1914. The increase is, of course, accounted for by the intensive shipbuilding work carried on in the United States during the war, with the object of making good the shipping losses due to the German submarine campaign.

Japan has more than doubled the tonnage of its merchant fleet since June, 1914, and now takes third place among the shipowning nations of the world, with a tonnage of 3,402,000, as compared with 1,642,000 tons just prior to the outbreak of war. France, Italy and Holland have each made material additions to their mercantile marines in the same period, the current figures for the tonnages owned by these three countries being 3,265,000 tons, 2,788,000 tons and 2,606,000 tons, respectively. Germany, on the other hand, now owns less than half her pre-war tonnage, which was 5,098,000 in June, 1914, and is now 2,496,000. The fact that the latter figure has been increased by 713,000 tons, or 40 per cent., during the past year, however, is an indication that our late enemies are sparing no efforts to regain their pre-war position in the shipping world. The other important maritime nations given in order of magnitude of tonnage owned are: Norway, 2,299,000 tons; British Dominions, 2,219,000 tons; Spain, 1,169,000 tons; Sweden, 1,092,000 tons; Denmark, 920,000 tons; and Greece, 743,000 tons. The last-mentioned country, it may be remarked, owned 820,000 tons of steel and iron sea-going steamers in June, 1914, and, with the exception of Germany, is the only nation whose merchant fleet has declined during the period.

It may now be of interest to refer to the changes that have taken place since 1914 in the relative positions of some of the more important maritime nations with respect to steel and iron steamers and motor vessels. Great Britain and Ireland, of course, still retain the foremost position, but while the proportion of the world's shipping owned in these Islands in 1914 amounted to nearly 44¼ per cent.,

the present proportion is just under 33 per cent. In pre-war days, Germany held second place among the maritime nations owning, as previously mentioned, some 5,098,000 tons of merchant shipping, which represented 12 per cent. of the world's total in June, 1914. Her present tonnage represents only about 4·3 per cent. of the total and gives her the seventh place in order of magnitude of tonnage owned, but, as previously pointed out, it is evident that Germany is by no means content with her present position. Austria-Hungary, which owned over a million tons of shipping in pre-war days, has now ceased to exist as a maritime nation. The United States, on the other hand, has risen from a position of comparative insignificance in June, 1914, and now owns the second largest mercantile fleet in the world. The present American tonnage, which as previously mentioned, is 12,416,000, constitutes 21·4 per cent. of the world's total, whereas the pre-war tonnage of 1,837,000 represented only 4·3 per cent. Japan now owns nearly 6 per cent. of the merchant shipping of the world, and takes the third place on the list as compared with the sixth place held before the war; while France, which now takes fourth place, has not altered her position relatively to the other nations having owned the fourth largest mercantile navy before the war. The French tonnage now represents 5·64 per cent. of the total and the proportions owned by the other nations are as follow: Italy, 4·82 per cent.; Holland, 4·5 per cent.; Norway, 3·97 per cent.; British Dominions, 3·83 per cent.; Spain, 2·02 per cent.; Sweden, 1·89 per cent.; Denmark, 1·59 per cent.; and Belgium, 1·04 per cent.

Although a considerable addition has been made during the past year to the British mercantile marine, the total tonnage of steel and iron sea-going steamers and motor ships now on the Register is practically the same as was the case a year ago, so that the tonnage of obsolete vessels broken up, or otherwise removed from service, has been about equal to the new tonnage added. At the present time, just over 29 per cent. of the tonnage owned in Great Britain and Ireland is less than five years old, whereas the proportion a year ago was less than 23 per cent. The general standard of efficiency of British shipping has therefore been increased during the year, which is obviously a matter of particular importance in view of the greater competition for freights to be met both now and in the near future. The British proportion of new tonnage is, however, lower than the average figure for the whole world, which is about 35 per cent., and is much below the proportion owned by some of our chief competitors. The American mercantile marine, for instance, now contains 57·3 per cent. of tonnage less than five years old and the corresponding figure for Germany is 52·6 per cent. Other merchant navies containing larger proportions of new tonnage than Great Britain and Ireland are Holland (37·8 per cent.), Canada (36·8 per cent.), Japan, (35·3 per cent.), and France (34·7 per cent.).

Tables included for the first time in the current edition of the Register Book give some interesting data as to the types of propelling machinery now in use. From these it appears that of the world's total tonnage of 65,166,238, 51,661,908 tons, or about 79 per cent., are still propelled by reciprocating steam engines, and 8,893,749 tons, or about 13·6 per cent., by steam turbines, while the tonnage of motor vessels is 1,321,131, and forms about 2 per cent. of the total. In addition to the latter, 345,254 tons of shipping are fitted with motor engines for auxiliary power, so that the total tonnage of shipping now employing liquid fuels in internal-combustion engines, amounts to 1,666,385, which is 2·56 per cent. of the whole world's tonnage; the corresponding figures for 1914, we may add, were 220,000 tons and 0·45 per cent. Oil is now used under boilers in 15,792,418 tons of shipping, of which 8,798,776 tons are owned in the United States and 3,792,676 tons in Great Britain and Ireland, as compared with a total of roughly 1,301,000 tons using oil for steam raising in 1914. The proportion of oil-fired tonnage has increased during the last nine years from 2·65 per cent. to 24·23 per cent. and, adding to these percentages those given above for the tonnage using oil in internal-combustion engines, it will be seen that oil is now used for the propulsion of nearly 27 per cent. of the world's shipping as compared with about 3 per cent. just before the war. Of the remaining tonnage now in existence, 68·87 per cent. uses coal as fuel and 4·34 per cent. is dependent upon sail power, the corresponding figures for 1914 being 88·84 per cent. and 8·06 per cent.

Much other interesting and useful information could be obtained from the valuable statistics included in the Register Book, but considerations of space will only permit us to refer to one other point, which is brought out by a new table showing the number and tonnage of vessels owned by the principal countries for each year from 1890 to the present time. From this table it appears that during each of the last three decennial periods, the additions to the world's merchant navies have totalled 9,265,000 tons, 13,468,000 tons and 17,885,000 tons, respectively, and it is particularly interesting to note that in spite of the varying conditions that have prevailed over the last thirty years—which, of course, included the period of the Great War—the proportion added during each successive interval of ten years has always been, roughly, 40 per cent. The actual increase for the first period, 1893–1903 was 38·2 per cent. and for the two subsequent periods, 40·2 per cent. and 37·8 per cent, respectively.

In conclusion, we should point out that the tonnages quoted above are gross in all cases, and we should also mention that vessels of less than 100 gross tons are not included in the statistics from which they have been taken.

THE PROGRESS OF AVIATION.

So much prominence has been given in recent weeks to the present state of civil aviation that the recently issued report of the Air Ministry covering the year ending March 31, 1923, falls a little flat. In February last the third Air Conference was held, and Sir Sefton Brancker gave a general review of the whole position. More recently, at the Sheffield Congress of the Institute of Transport, Sir Sefton took up certain points in more detail, particularly the relative safety of flying, &c. The recent International Air Conference in London has directed attention to other points, and as all these discussions have been duly reported in our columns it is unnecessary to refer to several of the subjects of the report just published. For those reasons we may dismiss without further mention, the sections dealing with the progress of international arrangements, and with subsidies and the proposals now under consideration by the Government, as well as the various changes which have been made in the British services.

The training scheme for the Royal Air Force Reserve of Officers is well in hand, four centres having been selected. The training will consist of 24 days per annum preferably taken quarterly, with special provision for officers who are out of practice on joining up. Officers on becoming competent will receive a retaining fee, and the training centre a capitation grant. It is to be hoped that every success will attend this development, as well as the further effort, not referred to in this report, to strengthen our position in the air through the Territorial Army. Ground organisation is receiving a great deal of attention and various developments have been referred to in our pages. The traffic control system at Croydon, sound location, new types of lamps and other aids to flying under unfavourable weather conditions, or by night, have shown practically useful results. Among the appliances experimented with has been a day and night wind indicator visible 3 miles or 4 miles distant, and needing no attention for six months at a time.

The factor of safety has been improved by changes introduced for the prevention of fire, fuel and cooling systems, &c. The three-engine type of machine is to be developed in order to minimise the risk of forced landings. For the Southampton route to France the twin-engined amphibian boat seaplane will be employed, and also a smaller single engined seaplane. For the Baghdad route a 1,000 h.p. machine with one or three engines will be developed, and for the Imperial route a three-engined machine having a petrol capacity of 1,300 miles against a 15 m.p.h. wind, will be employed.

In Australia two services are in operation. One Geraldton to Derby (1,195 miles) reduces an 11-days' steamer journey to two days by air. The other between Charleville and Cloucurray (560 miles) links up inland railways and now takes as many hours as the former means of transport did days. Other services are planned. Canada has used aeroplane services for transporting field parties in the forestry and other services, and in connection with the Indian Reservation work. Various other developments are reported from other parts of the Empire. In France the shorter routes are being abandoned and the longer services are being extended. Germany last summer had 15 air services in operation of which the chief was one from Konigsberg to Moscow. Another development proposed is a service to Petrograd and also to Persia. The United States air mail has been frequently referred to. With regard to the English services the year ending March, 1923, showed a very good degree of freedom from accident, the approximate machine-miles per accident, resulting in death or injury to occupants, being for the year 389,000. This was a much better figure than the years 1920 and 1921. In 1922 there were no accidents whatever to record for regular transport, but several in connection with other forms of flying. In the year of the report engine failures involving interruptions only accounted for 1·9 per cent. of the total flights commenced, the total flights commenced having been 2,090 and the total stoppages amounting to 15 per cent., of which proportion some were completed after a short delay only.

THE ECONOMIC SITUATION OF NORWAY.

DURING 1922 the trade and industry of Norway passed through yet another dark and critical year, marked by difficulties of a nature similar to those which characterised the year 1921; and although at the present time conditions generally show signs of improvement, there seems small ground for anticipating any material change in the economic situation for some considerable time to come.

A number of diverse influences have, during the past year, combined to set stringent limits to profitable production in a great many of the principal industries of Norway. Among these may be mentioned competition from countries with depreciated currency or cheaper labour, high cost of production due to the employment of raw materials purchased before prices fell to their present level, the existence of large stocks of manufactured commodities, and the increasingly onerous burden of taxation. These factors, coupled with lack of demand due to the financial stringency, have tended to decrease production and limit profits, and although the general decrease in the cost of labour which took place during the year brought welcome relief, this was largely offset by the still more marked decrease in the prices obtainable for industrial products. The decrease in wages has not kept pace with the decrease in prices, and it is anticipated that further wage reductions are inevitable during the present year.

During the past year the adverse trade balance, which has been such a marked characteristic of the past few years, was reduced, and a greater number of workers were able to find employment. The improvement in the volume of the export trade was not however, accompanied by a corresponding increase in profits, the prices obtainable for the goods in many instances failing to cover the cost of production, while in spite of the greater activity in shipping the shipowners experienced great difficulty in covering expenses.

Condition in the engineering, shipbuilding and allied industries have naturally suffered from the general financial and economic conditions which govern the present situation. During 1922 there were some 11,000 men employed in the mechanical and electrical workshops, foundries and shipyards, many of them on short time, as compared with twice that number in 1920. As in 1921, the situation has been characterised by a shortage of new orders, poor prices, and keen competition from other countries. Motor manufacturers are in a particularly unfortunate position owing to the financial depression in the fishing districts and competition from Swedish factories, which are stated to be realising their stocks

at low prices. The larger Norwegian factories are working on a greatly reduced scale, and many of the smaller ones are closed down. As regards shipbuilding, the demand for new tonnage is small, and very few contracts have been placed in Norway, a number of contracts for Norwegian owners having been placed with British, German and Danish yards. For repair work British yards are reported to be the most serious competitors of the Norwegian shipwright.

During 1922 no new hydro-electric power schemes have been projected, but work has proceeded upon a number of schemes previously initiated by the State and various municipalities, many of which are now approaching completion. Work has, during the year under review, proceeded with the 20,000-kw. transmission line from the Rjukan power station to Christiania and Drammen, which is now practically complete, while in connection with the Nore power scheme work has progressed satisfactorily on the tunnel and catchment basin. The Hakavik installation has also been completed and electric trains placed in operation between Christiania and Brageroen, which is connected to Drammen by a bridge crossing the Drammen River. This structure is, however, not of sufficient strength for the loads involved, and a new bridge is to be constructed. Another large scheme which has been completed during the year is the 77,000-h.p. installation at Glomfjord, while the low-pressure station at Raanaasfos, on the Glommen River, has also been completed and placed in operation, six units of 12,000 h.p. each being at present available. Several other municipal power schemes have also been completed since the beginning of 1922, including that at Kristiansand, to harness the Nomeland Fall, and the Nord Trondelag county scheme on the Folla watercourse. Work on a new scheme, which will develop a horse-power of 100,000 has been commenced by the Bergen Municipal Power Company at Dale.

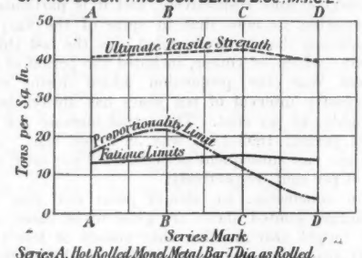
Taking conditions throughout the country as a whole, and comparing the general situation as it exists to-day with that of a year ago, it is clear that some progress has been made during the past year, and that many obstacles to economic recovery have been removed. Conditions are still, however, very difficult, and the state of public finances throws its shadow over the whole situation. It is, therefore, difficult to form any opinion as to the prospects of trade and industry during the present year. The absorption of stocks and the general increase in industrial activity would appear to indicate the possibility of improved conditions, but a further reduction in the purchasing power of the general public is anticipated, and a great deal depends upon the development of events outside Norway. On the whole, however, it may reasonably be expected that the tendency towards recovery which has characterised the past year will continue, and that 1923 may see a general improvement in industrial and economic conditions throughout Norway.

THE FATIGUE LIMIT AND PROPORTIONALITY OF MONEL METAL.

THE proportionality limit of non-ferrous metals is changed by cold-working, and it also alters with the temperature of finishing when it is hot rolled, and in this case it is, moreover, a function of the dimensions of the bar. Monel metal is no exception to this general rule, and some of those desirous of taking advantage of its high tensile strength and exceptional toughness have been somewhat disturbed by these variations in the proportionality limit, although in the case of the ferrous metals, at any rate, there is no close correlation between the endurance of a material and its elastic limit. In order to be in a position to satisfy inquirers as to the physical and mechanical significance of these variations, Messrs. G. and J. Weir, Limited, Cathcart, Glasgow, consulted Professor T. Hudson Beare, of Edinburgh University, who offered to make an investigation of the endurance of Monel metal specimens prepared in different ways. The experiments were made with a Haigh alternating stress machine, the materials being pieces of hot-rolled bar taken from stock; and to these were added specimens drawn cold to a circular form. Although the proportionality limit in the different specimens ranged from 4 tons to 21·2 tons per square inch, the investigation showed that the fatigue limit varied remarkably little, ranging only from 13½ tons to 15 tons per square inch. These results seem to show that there is even less correlation between the proportionality limit and the endurance limit for this material, than is found to be the case with steel.

With Monel metal as with steel the endurance limit seems to be very closely connected with the ultimate strength of the material, and to depend but little on the elastic limit. The results of the fatigue tests carried out at the Edinburgh University are plotted in Fig. 1, and whilst Fig. 2 shows the result of tests made at Messrs. G. and J. Weir's to determine the effect of low temperature annealing on the proportionality limit of Monel. With steel, there is found to be a very fair correlation between the endurance limit of the material and the Brinell tests, and this appears to hold also with Monel metal. Thus with a series of 9 specimens on which the proportionality limit ranged from 10·3 up to 29·2 tons per square inch, the range of Brinell numbers was from 163 up to 217. The lower figure is, however, unfairly low as the specimen in question had been heated to 800 deg. C. and rapidly cooled. This specimen had a proportionality limit of 18·4 tons per square inch.

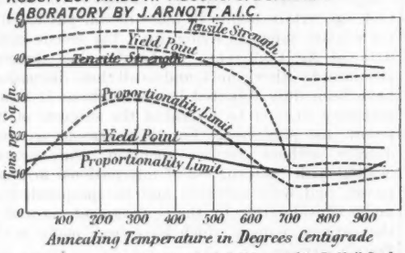
Fig. 1. DIAGRAM SHOWING THE RESULTS OF FATIGUE TESTS ON MONEL METAL BARS MADE AT THE EDINBURGH UNIVERSITY BY Mr. W. GORDON B.Sc., M.I.M.E., UNDER THE DIRECTION OF PROFESSOR T. HUDSON BEARE B.Sc., M.I.C.E.



Series A. Hot Rolled Monel Metal Bar 1 Dia. as Rolled.
" B. 7/8 Cold Drawn from 1 1/16 Hot Rolled Bar & Annealed.
" C. 15/16 " " " " " " & not Annealed.
" D. ½ Whit. Hex. Bar Cold Drawn from 1 5/16 Hot Rolled Bar not Annealed.

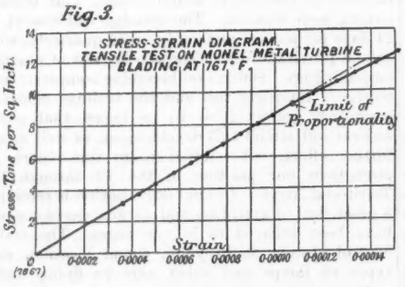
The above Curves show how the Fatigue Limit follows the Ultimate Tensile Strength, & is not affected by Variations of the Proportionality Limit.
The Fatigue Limit Curve is compiled from Experiments which covered Reversals up to 16,848,000 on Unbroken Specimens.
(1930 A)

Fig. 2. CURVES SHOWING THE RELATION BETWEEN THE ANNEALING TEMPERATURE & PROPORTIONALITY LIMIT, YIELD POINT, & TENSILE STRENGTH OF MONEL METAL RODS. TEST MADE AT MESSRS. G. & J. WEIR'S LABORATORY BY J. ARNOTT, A.I.C.



Dotted Lines: 5/8 Cold Drawn Rod. Full Lines: 3/4 Hot Rolled Rod.
(1930 B)

Fig. 3.



(1967)

For comparative purposes, therefore, it would be fairer to take the Brinell range as from 187 to 217, whilst, as stated, the proportionality limit ranged from 10·3 up to 29·2 tons. Messrs. Weir have also had some further experiments made at the National Physical Laboratory, with finished turbine blades of Monel metal, in order to determine the variation of the elastic properties with temperature. The specimens had an area of 0·325 sq. in., and were held in specially-made grips. The results observed were as follows:—

Temperature of specimen ...	Room temperature	767 deg. F.
Area of specimen sq. in. ...	0·325	0·325
Limit of proportionality, tons per sq. in.	13·9	9·2
Yield stress, tons per sq. in....	37·7	31·2
Ultimate stress, tons per sq. in.	41·9	36·4
Modulus of elasticity	...23·9=10⁶	19·3×10⁶
Elongation on 2·3 ins. ...	—	16·5 p.c.

We reproduce in Fig. 3 annexed a graph which shows that even at this high temperature the elasticity of the metal is practically perfect up to 9·2 tons per square inch.

THE CONVERSAZIONE OF THE INSTITUTION OF CIVIL ENGINEERS.

THE annual conversazione of the Institution of Civil Engineers, which was held on July 12 in the Institution building, Westminster, was notable this year for the number of distinguished foreign engineers present, the Council having extended invitations to members of the International Congress of Navigation whose London conference had just closed. Members of the Institution also attended in large numbers, and the capacity of the building, great as it is, was fairly taxed to accommodate the guests, who were received in the Great Hall by the President (Dr. W. H. Maw) and Mrs. Maw. As is the custom of the Institution, an extensive and varied programme of entertainments was provided. In addition to the vocal and instrumental music contributed by the string band of the Royal Engineers and various accomplished artistes, the visitors had the opportunity of hearing lantern lectures by such experts in their particular subjects as Sir Henry Maybury, who gave "Stray Thoughts on Roads"; Sir Frederick Young, who spoke on "Sea Salvage"; and Mr. Sidney Preston, who told of "Fifty Years' Work of Irrigation Engineers in India." There was also a very interesting demonstration of Rapid Cinematography by Mr. Walter Heape in the South Reading room.

In the Upper Committee room were displayed models and other exhibits of historical engineering interest, including models of early locomotives lent by the South Kensington Science Museum, specimens of the first submarine cables, Bradshaw's Railway Guides dating back to 1839 and 1845, a drawing of a waterworks pumping engine designed by Smeaton in 1784, and numerous other relics of the past. In the Museum of the Institution were to be seen the collections of specimens illustrating the deterioration of materials exposed to sea action, and other corrosive influences, but the display of engineering models and scientific apparatus in the Library was the centre of most general interest. Many of the exhibits shown have already been illustrated and described in our columns, such as the Fereday-Palmer stress-recorder for giving a graphic record of the straining which takes place in the members of railway bridges or other structures when subjected to varying loads, and the Cambridge stress recorder designed for a similar purpose. Mr. J. S. Wilson's "Telechron" transmitter for indicating at a distance water levels in reservoirs has also recently been dealt with in ENGINEERING, and in a future issue we propose to illustrate and describe the gear-measuring machine of Mr. G. A. Tomlinson, shown by the National Physical Laboratory. The machine is of too complicated a nature for justice to be done to it in a short paragraph.

It is impossible to deal in this notice with more than a very few of the exhibits but two at least deserve special mention, namely, the Hele-Shaw stream-line filtering apparatus and the treatment of dust by a colloidal bituminous solution, shown by Major-General Sir George K. Scott-Moncrieff. The

results obtained by Dr. Hele-Shaw's filter were very striking even to those who have not had practical experience of the difficulties of clearing liquids from the exceedingly minute particles which will pass unchecked through any form of sand filter, or even through filter paper. Even more difficult would it appear to be to get rid of the colour of a true solution, yet solutions of so-called fast dyes when passed through the apparatus came out as colourless as water. The invention of the stream-line filter arose from experiments by Dr. Hele-Shaw on the properties of excessively thin films of liquid in which he discovered that streams of dyed liquid lost their colour when passed between surfaces almost in contact. The commercial form of the filter as shown at the conversazione, consisted of 7,000 sheets of waterproof paper piled together and contained in a casing only 30 in. high and 12 in. square. The sheets were perforated with a number of circular holes which formed vertical tubes or ports in the pile. Alternate rows of holes were connected together so that one-half of the whole number acted as inlet ports and the other half as outlet ports. The raw liquid had to pass from one set of ports to the other by traversing the exceedingly narrow passages between the sheets of paper. The filter shown would filter 200 gallons per hour of water in any state of dirtiness, giving a perfectly clean and limpid effluent. The paper is quite smooth and waterproof, the action being entirely due to the film effect. Cloudiness in oil, due to molecular combination with water, can be removed, as the filter will separate the water from the oil. The filter can be cleaned in a few moments as the impurities are retained round the walls of the vertical ports from which they can easily be washed. The stream-line filter has been tried experimentally on sewage, gasworks effluents and trade-waste effluents, and in all cases it successfully accomplishes the work desired, whether the valuable material is the effluent or the retained residue.

The exhibit of Sir George Scott-Moncrieff had two very important bearings, one the prevention of coal-dust explosions in mines, and the other the removal of the dust nuisance on roads. In both cases the problem is to find some way of causing the dust particles to adhere together in conglomerations of sufficient size and weight to prevent them from remaining suspended in the air.

To secure this result, Mr. John Hines, the inventor of this process of treating dust, takes as his basis Mexican bitumen, a residual product of the oil refineries, and makes a colloidal solution of this with the tar oil from gas works. This mixture is then emulsified with water, the final product being composed of 15 per cent. bitumen, 35 per cent. tar oil and 50 per cent. water. It is a true permanent emulsion, the Brownian movements of the oil particles being easily visible under the microscope. Ten per cent. of the emulsion is added to 90 per cent. of water, with which, of course, it will readily mix, and this is used for laying the dust. In due time the water evaporates, leaving the dust particles coated with bitumen.

So effective is the mixture and so permanent are its results that a road in one of the London boroughs remained dustless for three months after treatment, whereas previously it had been necessary to water once a day. The effect of the emulsion is to restore cohesion to the dust particles, so that they are undisturbed by vehicles or wind. The roads around Epsom were treated in anticipation of the Derby day traffic, with very great effect on the comfort of those who used them or dwelt alongside. We shall have more to say about this process of dust treatment on a future occasion. At present we are only describing its chief features, but we may mention that the commercial development of the process is being carried out by Roads Colloidal, Limited, who have established works at Stratford, E.

The classification of fine powders by "elutriation," or dividing them into grades by means of water currents, was demonstrated by Mr. Leonard Andrews, the lighter particles being carried off to their own receptacles by properly adjusted and ingeniously arranged upward currents of water. This was also an exhibit which cannot be dealt with fully in a notice like the present. The exhibit of Mr. Harry J. Fereday was particularly interesting on account of the ingenious type of motor used to wind the films and synchronise the diagrams of his stress recorder, and we hope to illustrate the device in a future issue, as without illustrations a description could hardly be made intelligible. Mr. J. L. Hodgson showed a new flow-meter for steam or water, in which the indicating and recording apparatus was driven electrically and could be erected at any desired place, such as the engineer's office, or the control cabin of a boiler room. A working model of the "Coacta" automatic railway coupling was shown by Mr. J. M. Dobson, the device being designed to suit side-buffer vehicles without requiring any alteration of the drawgear behind the headstock and without interfering with the use of link or screw couplings. Mr. Frank Gill showed the piezo-electric effect in crystals of Rochelle salt, which became electrified if compressed in an axial direction. The piezo-electric property of crystals was, of course, made use of during the war for the detection of the nature, duration and magnitude of sudden shocks such as those produced by the explosion of submarine mines. The electrification of the crystal by the shock was caused to charge a pair of insulated plates in a vacuum tube, and thus to deflect the path of a pencil of cathode rays, the deflection being recorded on a photographic plate which the rays struck.

NOTES.

WATER PURIFICATION PLANT AT BECKTON GAS WORKS.

THE Beckton Works of the Gas Light and Coke Company, which are situated on the Thames near Barking, are, we believe, the largest gas works in the world and are certainly the largest in Europe. They gasify about 1,300,000 tons of coal and produce some 17,500,000,000 cub. ft. of gas per annum, as well as coke and chemical by-products of all kinds. We briefly described the main equipment of the works on pages 809 and 824 of Vol. CXIII of ENGINEERING, but since that time an important plant for the purification of the water required for various industrial purposes throughout the works has been constructed and put into operation. This plant, which by the courtesy of the Governor and directors of the Gas Light and Coke Company we were able to inspect on Tuesday last, was designed and constructed by Messrs. United Water Softeners, Limited, Imperial House, Kingsway, W.C. 2, and is capable of treating 4,000,000 gallons a day. The plant is housed in a reinforced-concrete building and the water is raised from the Thames by submersible pumps, which are used owing to the high and variable lift necessitated by the tidal range of the river. Lime is used as a reagent for coagulating the mud and other suspended matter in the water, and also for the removal of free carbon dioxide, which is an active agent for corrosion. After the addition of lime, the water passes through sedimentation tanks, remaining in these for 6 hours, during which time the bulk of the suspended matter settles out. The final purification is effected in sand filters, which are provided with compressed air agitation for cleansing purposes. The water, after treatment in this way, is used for the condensers and also for coke quenching, and since some surprise may be felt that purified water should be employed for such purposes, we may explain that much trouble was previously experienced from the frequent choking of the sprayers due to the use of river water. The installation, we understand, has now been working satisfactorily for about two months, and it is certainly an interesting example of an industrial water-purification plant.

DETERMINATION OF THE DENSITY OF CHARCOAL.

The determination of the density of porous and powdered substances is a very difficult matter. When volume and weight are measured in air or some other gaseous medium, the amount of gas present is uncertain; pumping does not remove all the gas, and gas expulsion by heat would mostly lead to decomposition. Similar difficulties are met with when the substance is placed in a liquid. Like the gas, the liquid is "sorbed" by the solid particles; it is adsorbed and condensed on the surface, and then absorbed by penetrating into the interior. The forces involved may be both physical and chemical. In the case of indifferent materials like charcoal chemical affinity may appear to play no part, but it is well known that charcoal absorbs different gases to different degrees and will take up hydrogen, but not helium, from the residual gas in a discharge tube. From a paper on the "Determination of the Density of Charcoal by Displacement of Liquids," read recently by Dr. J. B. Firth, of Nottingham, before the Faraday Society, it would appear improbable that we shall succeed in settling more than the apparent density of charcoal under certain conditions. Dr. Firth prepares a cocoanut charcoal of 1·2 per cent. of ash by carbonising at low temperature and reduces the ash finally to 0·37 per cent. by digesting the charcoal with hydrochloric acid and water. The charcoal is finely powdered in an agate mortar and transferred to a quartz flask which is evacuated at 600 deg. C.; the tubular connection with the pump is then placed in the liquid to be used, and the flask is half filled with liquid, air being admitted into the other half. The flask is shaken, and part of its contents is charged into a gravity bottle which is kept in a thermostat; volume and weight are determined at intervals, and the charcoal is finally filtered off, dried at 150 deg. C. and weighed. Experimenting in this way with the liquids water, alcohol, chloroform and benzene, Dr. Firth found that the apparent densities of the charcoal increased with time in all cases. In water the density was after 3 minutes, 1 day, 50 days: 1·849. 1·855, 1·904; in alcohol, 1·897, 1·920, 2·001; in benzene, 1·874, 1·896, 1·958. These figures apply to cocoanut charcoal; the figures for sugar charcoal were all smaller, being in water, 1·641, 1·663, 1·786. Thus the density of the charcoal was always lowest in water, lower even than in benzene, though the benzene molecules are large and the capillary forces in benzene are small. The interpretation of the complex phenomena is difficult. In addition to capillary forces, viscosity and gas pressure there may be polymerisation of the liquid molecules adsorbed and chemical reaction. Dr. Firth did not point out in his paper that the liquid would have to displace air in the pores of the charcoal; that displacement might be very slow, which might account for the gradual rise of the density for 40 days when constancy seemed to be attained. He was not present to answer the objection raised. But there are various sources of possible errors in his experimental method and would probably be in any other method. The discrepancies in the results of similar experiments made by other investigators may be due to the different methods employed.

LITERATURE.

A Comprehensive Treatise in Inorganic and Theoretical Chemistry. By J. W. MELLOR, D.Sc. Vol. III. London: Longmans, Green and Co. 1923. [Price 63*s.* net.]

DR. MELLOR, by adding another volume to the two published last year (ENGINEERING, July 28, 1922), has made substantial progress with the gigantic task he has undertaken in attempting to describe all that is known of the compounds of inorganic chemistry. The collection and examination of the immense mass of data serve as a general stock-taking, giving clear indications of the progress made and of the lacunæ that have to be filled. The process necessitates a digest of many scientific transactions and technical journals, English and foreign, but this labour does not exhaust the programme the author has proposed to himself. He makes excursions into many by-paths, bordering on physics and philosophy, which bring an air of originality into the inquiry, and stamp the treatise as something more than a mere book of reference. No doubt Dr. Mellor is assisted by a large and competent secretarial staff, who collect the material from the sources in which it originally appeared, but the work of combination, as well as that of rejection, must be his own. The number of pages that consist solely of references testify to the industry, and as far as we have been able to test, to the accuracy of the working corps and to the pertinence of the extracts. The rapidity with which the successive volumes are appearing proves that Dr. Mellor does not intend that his work shall share

the ignominious fate of the seventh edition of Gwelins' ponderous treatise, which began in 1905, and still remains unfinished. There are, we believe, other works that are painfully dragging their slow length along, and such dilatoriness is regrettable, for much of the value of these encyclopædic collections, referring to progressive science, is lost, if by a want of approximate simultaneity in the record they fail to convey a just estimate of the position at a particular epoch. With so many workers, increasing in a geometric ratio from year to year, the facts multiply so fast that in some directions the information is superseded or grown out of date, while the work is under compilation. An opportunity for reducing the evils of repetition and overlapping is lost.

This volume may be conveniently divided into two parts, and treats of six metals, the earlier portion being devoted to copper, silver and gold, the latter to the alkaline earths, calcium, strontium and barium. The plan of description follows similar lines in each of the six elements. A few remarks on the early history of the metal serve as an introduction, and in this volume as in the two preceding, the author shows how thoroughly he is versed in the literature of the older chemistry, and how well he can quote some quaint fact to illustrate or to enliven the collected details. Then some account is given of its method of occurrence and distribution, leading to a brief description of the processes pursued in metallurgy and in the separation from its compounds. Next, the main chemical and physical properties, including the determination of the atomic weight, are given in some detail. The great mass of extracts is naturally centred round the preparation and discussion of the compounds of the several metals, and these generally follow the order, oxides, chlorides, bromides, sulphides and sulphates, nitrates and phosphates. This order is fairly well preserved, though naturally variations may be desirable owing to peculiarities of chemical behaviour or to the commercial importance of some compound having attracted unusual attention. As an example, copper may be instanced where the cuprous and cupric oxides each form the base of a characteristic series of salts, while the action of light on silver halides will lead to a discussion of the latent image, and the use of nitrates and chlorides in photography. The point we would make is, that while the author recognises the convenience of maintaining uniformity he does not allow himself to be hampered by adhering too strictly to a programme.

The description of the alkaline earths, or perhaps it would be better to say the compounds with calcium, strontium and barium, respectively, strikes one as equally exhaustive as the work in the earlier part. Magnesia is not included in this section and will probably appear in connection with cadmium and zinc, while radium, which has been included in the family of the alkaline earths, will find a place at the beginning of the next volume in common with the actinium families. It is convenient to treat the three elements just mentioned under one heading, since they display a close kinship and their chemical activities of the properties depend upon, or at least apparently coincide with, the change in their atomic weights.

We congratulate the author on the headway he has made, a happy augury that he will carry his work to full fruition. Our gratitude no less than our respect is demanded by the courage and energy exhibited in undertaking the responsibility of producing, without collaboration, so comprehensive a treatise on general chemistry.

Cements, Limes and Plasters; Their Materials, Manufacture and Properties. By EDWIN C. ECKEL, C.E. Second edition, revised and partly re-written. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 32*s.* 6*d.* net.]

THE cement industry is one of rapid and continual change, both as regards the selection of the ingredients and the processes of manufacture. To attempt therefore to give a description of the technology prevailing throughout the industry at the present day, based on the materials that served in the early years of the century, is to undertake a task of doubtful expediency, and in this case we cannot say that the result is entirely satisfactory. The author has extensively revised the old, and added new, matter, but the interval, whether in time or measured by progress, is too great to be covered in one step. When the first edition appeared the manufacture of Portland cement was of comparatively small extent in the United States, and overshadowed by the larger European output, longer experience, and traditional methods. Foreign manufacturers by controlling importation, fixed American prices, and the change that was to be effected in a few years was unforeseen. Towards the end of the last century, however, the rotary kiln had come into operation, bringing with it the great increase in length and capacity, which made vast economies possible and revolutionised the whole process of manufacture. The advantages of the modern kiln were particularly seen in the wet mix, and these were even made more conspicuous by the introduction of powdered coal and the use of other and cheaper fuel. Enormous increase in output with considerable reduction in price were the natural consequences. In 1895, the total home production was less than 1,000,000 barrels, at an average value of 2·50 dols. per barrel. In 1920, the output exceeded 100,000,000 barrels, while the price per barrel diminished to 81 cents. The technology, chemical and physical, has varied proportionately with the extent of manufacture, and the industry has to be surveyed from a different standpoint from that which sufficed when the century was younger.

The literature, too, has changed, and though we may admit the extent of the revision and the value of the additions, it is difficult to accept the statement that the references have been brought up to date. It is true that a bibliography has been attached to each chapter, but references to original contributions, later than 1905, are few and far between. Investigation and research have been vigorous in the interval, and though we may respect the work of Newberry and Le Chatelier, we are not the less anxious to be put in possession of the results of later investigators, viewed from the standpoint of practical experience. One would not gather from these references, for example, that the staff of the Geophysical Laboratory at Washington has achieved much brilliant work, and has succeeded in placing the physico-chemical relations throughout the whole process of cementation on a satisfactory basis. We believe we are correct in saying that the only allusion to this laboratory refers to the work of Mr. Rankine, apparently in connection with researches on the chemistry of silicates, but the reference is vague. Moreover, it is not a little annoying to find the word "recently" applied to events that happened twenty years ago. A convention of sand-lime manufacturers is mentioned as of "recent" occurrence, but the meeting was held in 1904, and the description of the extraction of carbon dioxide from magnesite is taken from a "recent" report, dated 1903. When later we are told that no hydrated lime is "at present" made in this country, it is impossible to conclude when the practice was abandoned.

Although we have thought it necessary to utter a word of warning concerning the method on which the work has been constructed, it is not to be inferred that the treatise is other than a work of great value. Written for Americans and dealing with American practice, which differs in many respects from that followed in Great Britain, the work has many advantages and particularly in the universality of the survey. Something will be found relating to every branch of the cement industry. Starting with the distribution of cementing materials throughout the United States and a description of the qualities that determined their selection and usefulness, an especially good account is given of gypsum firing, and the preparation of plasters. It is important to notice, that though the American production is large and increasing, an important trade is still carried on in European plaster of Paris, and in 1913, the last normal year, some 400,000 tons were exported from Europe. The Canadian trade is nearly stationary, an increase in that of Ontario being offset by a decline in other provinces. Limes and the sand-lime brick industry are fully treated in another section, but the number of operating plants is reported to be falling off. The output was at a minimum in 1918, but shows a slight increase since the war. Magnesite bricks used for furnace linings are noticed, and also oxychloride cements, which latter preparation has, however, but a small demand, outside dentistry. In the section devoted to hydraulic limes we hear much of the "Cementation Index," a formula which it is proposed to substitute for the "Hydraulic Index." To judge from the frequent recurrence to this subject and the number of examples worked out (apparently there is an error in the one on page 367) the artifice seems to be troublesome and difficult of application, and if used in America, has not found wide favour in this country.

The fifth and sixth sections which include more than half the book, are the most important, for in these are described the processes involved in the manufacture of Natural and Portland cements. The descriptions are very full and satisfactory, the author being apparently in his element among the famous Lehigh Cement Rock Works. A more critical attitude towards the effect of the addition of ground blast-furnace slag, of suitable composition, to the Portland cement would have been appreciated, for a considerable difference of opinion exists in this country, respecting its beneficial effects, although the general tendency is to support the finding of the Bureau of Standards, who recommend its use. The opportunity and prospect of turning a bulky and troublesome waste product to valuable use are inviting. Reference is again made to blast-furnace slags in connection with puzzolanic materials and a comparision between English and American practice is instituted, but definite information is wanting. The author has an extensive practical experience of cement manufacture, gained in several countries, and the exhibition of the differences of detail pursued would have added to the value and interest of the volume.

The Destructive Distillation of Wood. By H. M. BUNBURY, M.Sc.(Bris.), B.Sc.(Lond.). London: Benn Brothers, Limited. 1923. [Price 35*s.* net.]

AT the outset the author makes the statement that no English book dealing exclusively and comprehensively with the subject of wood distillation has yet appeared. Of course, the physical and chemical properties of wood have been described many times by writers on cellulose and allied industries, and such products as acetic acid, wood alcohol, acetone, &c., have attracted many students, but a complete survey of the problems presented by wood distillation, notwithstanding its ancient origin, has not been attempted in its entirety. The possibilities of wood have been overshadowed by the wider application of coal and its derivatives, and the more interesting developments have been the outcome of fairly recent investigations. Mr. Bunbury seeks now to remedy this deficiency, and to make easily available the information scattered through scientific and technical journals. The digestion of this varied material requires an expert chemist and a skilled engineer, and the author proves himself equally competent in both capacities, and if a botanist is needed he is still equal to this demand. He is familiar with every operation through which the raw material passes. The flow sheets exhibit at one end the trees growing in the forests, and at the other the gathering of the pyroligneous acid, tars, and gases, whose transformation by mechanical and chemical means into the forms in which they are used, vitalises dependent industries and continues the cycle of business enterprise.

In the slight preliminary history that introduces the subject we are reminded once again of the modernity of scientific industry. The Egyptian utilised the products of the carbonisation of wood in the work of embalming, and wood tar was used in the days of Pliny for caulking the seams of wooden ships, but for many generations, mechanical ingenuity could go no further. Charcoal and tar remained the only products of the inadequate treatment that has survived in some shape to our own days. In 1793, Lowitz produced acetic acid from wood distillation, but development on an extensive scale has been reserved for the last few decades. Acetone was identified in 1835, but it was not made from calcium acetate till 1880. The list might be extended indefinitely, and no doubt as coal grows more expensive in consequence of the exhaustion of the measures, the importance of wood as a substitute will be better appreciated and new applications will

be found. For by the use of wood we are not squandering irreplaceable capital, and the extravagance of one generation can be corrected by the frugality of the next.

One of the problems of the near future, and one which is discussed by the author in a very effective manner, will be the more profitable use of the products of wood in industry and the arts. The utilisation of wood waste, such as chips and shavings, sawdust and nutshells, of which it is estimated some 150,000,000 tons have to be destroyed without any economic return, is an attractive proposition that appeals to the economist, and already some of the initial difficulties have been overcome. The experience gained in the war showed that wood could be made to yield gas both for illumination and power at fairly remunerative prices. In countries where coal has to be imported, and in others, where labour unrest interferes with the due working of the coal mines, the properties of wood, fitting it as a gas-making material both in retorts for illuminating purposes, and in producers for power and heating, is receiving much attention. A mixture of wood and coal is apparently preferred in Switzerland, but wood alone is found to give very good results, and as scientific research and mechanical skill make advances, even more favourable reports may be anticipated.

The general theory of the destructive distillation of wood is largely of the nature of speculation, and the occasional and inexplicable variations encountered in the past, account in some measure for the stagnation that has affected the industry. It is true that a vast number of products are obtainable and have been obtained, and it is known that the yield and quality of these are influenced by the nature of the wood and the conditions under which the distillation is effected. But the character of the variations that should be introduced to counteract bad conditions and improve results, is less definite. Experiment has been the main, or the only, guide, and even now in spite of what has been achieved in the laboratory and in practice, the chemist may hesitate to give his sanction to some of the theories that have been suggested to explain the processes involved in the reactions. But such doubts hardly interfere with commercial practice and future development. Of more importance in affecting the manufacture is the tendency to adhere to obsolete plant. In the face of falling demand, it is difficult to find capital for modern installations, and so we find, for example, the pot-still being maintained in use in spite of the lower efficiency accompanying such appliances. The simpler apparatus is comparatively inexpensive and can be made to serve many useful purposes, more or less successfully, while the elaborate continuous stills will only serve the purpose for which they are specially designed. With the pot-still, however, the degree of separation is very inferior: it is impossible, for instance, to obtain a methyl alcohol of 99 per cent. purity without having recourse to repeated distillation.

The industry has suffered a great setback on account of the war, and is in need of a stimulant. Such a book as this should exercise a quickening influence, since it exhibits not only the principles that guide the mechanical and chemical processes of wood distillation, but describes the most appropriate plant at each stage of the process. There is little or no attempt to follow the alluring paths that lead to the manufacture of the many subsidiary products that make wood distillation desirable. It is rather concerned with the preparation of the raw materials for those weird transformations, which are so inviting. But within its limits it constitutes a safe guide, and should be consulted with confidence.

The Prevention of Vibration and Noise. By ALEC B. EASON, M.A., A.M.I.E.E. London: Henry Frowde and Hodder and Stoughton. [Price 15*s.* net.]

THE author of this book has been engaged in tracing the cause and providing remedies for the annoyance occasioned by vibrations due to the rotation of heavy machinery and other mechanical operations. In the pursuit of his professional work he has found it necessary to collect the recorded experience of many engineers and physicists, and in this treatise his object is to make the information useful to those who may be engaged in similar inquiries. Every authority quoted is accompanied by a reference to his original work, and though this scrupulous attention to the claims of originality is of great value by facilitating reference, the work would have been more pleasant to read, if the author had assimilated the materials more thoroughly and presented a less disjointed picture, in which due emphasis on the salient points assisted the perspective. The wealth of detail collected as the result of wide reading has had the effect of obscuring features it was desirable to see clearly. Yet one cannot but be aware of the author's eagerness to place at the service of workers in technical science whatever may prove useful in overcoming a very troublesome and often baffling annoyance. Remembering the difficulties to be encountered we commend the author's decision to refuse to discuss matters of which he has no direct experience, declining to repeat the statements of others of whose adequacy he cannot judge.

A large literature has collected around this subject of vibration set up by the motion of unbalanced machinery, as shown by the number of references to the expedients tried to overcome the trouble, and the description of the instruments constructed to measure the amplitude of vibrations. Our own columns will illustrate the interest and importance of the subject, but notwithstanding the ingenuity displayed in many instances, the remedies remain tentative and experimental. We must admit, however, that one engineer effectually solved the whole problem by the remark, that the proper remedy for vibration was to be found not in the installing of isolators, but in demanding perfectly balanced machines from the makers. A counsel of perfection, no doubt, but one that hardly comes within range of practical economics, for a long while yet we must endeavour to supply improved isolating supports to fairly well-balanced machinery, rather than to struggle after an unattainable perfection whose slightest deviations might be revealed if resonance existed.

The author recognises two distinct steps in the problem of vibratory effects, one when motion becomes susceptible, and the other when the amount is sufficiently great to cause annoyance. There can be no sharp defining line between the two, because susceptibility differs so widely in individuals, and we have no standard of the measurement of irritability. This want of uniformity is shown in the examples quoted, where attempts have been made to determine the minimum amplitude of vibration requisite to produce perceptible motion. In an experiment in which many people participated, 21 observers were unable to detect a velocity 0·02 cm. to 0·04 cm. per second, and six described the motion as very faintly perceptible. Three observers were conscious of a velocity of 0·02 cm. per second, and seven did not perceive any motion till the amplitude exceeded 0·10 cm. per second. Such relatively large variations do not permit of any accurate decision, and indeed, it does not appear that experimenters have settled on an absolute criterion of susceptibility, some accepting the extent of excursion to and fro', others, the acceleration, in which the square of the frequency enters, and others again, the total impulse which involves the cube of the frequency. Mr. Eason's remark that human susceptibility is probably independent of the frequency is apparently warranted, because if the frequency were greater than 5 per second, probably it would be impossible to perceive the pauses between successive blows, and there would be no cumulative resonant effect. That greater certainty has not been derived through the use of instruments designed for the exact measurement of the forces involved is possibly explained by the existence of psychological effects, which vibratory instruments are powerless to measure. Many instruments in use are well described and illustrated, and seem well adapted to their purpose, though in some cases the absence of damping appliances, other than that supplied by friction with the atmosphere, might diminish the value of the record. When instrumental records have been attempted on buildings in which machinery was installed, the operators were always inclined to think that the vibrations were more severe than the instruments indicated, and sometimes considered the soundness of the fabric imperilled, though the records proved the vibrations to be very slight. Evidently subjective influences are at work of which instruments can take no cognisance.

Passing from such small frequencies as those occurring in mechanical vibrations to the much greater frequencies met with in acoustics, another class of problems arises connected with the transmission of sound. The author admits that he has touched only the fringe of the subject, and we think he would have been well advised to have left these acoustical problems outside his purview. He has evidently had but little practical experience of these problems, which attack quite a different class of phenomena, and his acquaintance with the literature of the subject does not appear to be intimate or thorough. His acoustical work contrasts very unfavourably with the competency exhibited when discussing the mechanical problems which arise in connection with isolating supports and the treatment of artifices by which the evils of vibration are overcome. And again, we find him at his best in describing the methods of detecting the amount and position of unbalance in rotating machinery, as rotors and armatures. The treatment here, as in other places, is elementary, but sound, and those unfamiliar with the subject will find the collection of facts an excellent introduction to a wider treatment.

American Machinist Gear Book. By CHARLES H. LOGUE. Thoroughly revised by REGINALD TRAUTSCHOLD, M.E. Third edition. London: McGraw-Hill Publishing Company, Limited. [Price 15*s.* net.]

TEXT BOOKS on Gears are now numerous. The third edition of one of these, that now before us, illustrates the rapidity with which later developments have advanced. Matter in previous editions relating to costs has been omitted because of the recent developments in methods of production, as is also that concerned with practical points in gear cutting, because these are of little value in the present methods of gear generation. The work is largely a compilation from the *American Machinist*, contributed by various writers, but the selections have been made judiciously, and they include the latest developments in design and practice. There is, we believe, no single volume that contains so comprehensive a survey of the subject as this one does. The various gears are treated in 16 chapters, not in a strictly conventional manner, but from the aspect chiefly of first principles. The book is a suggestive one, in the sense that its perusal leaves one painfully aware how little is really known with certainty of the laws that control the working of the numerous forms of gears.

The influence which the adoption of generating methods has had on tooth formation is fully dealt with in the first section. The interferences of the strictly involute tooth are illustrated, and a comparison drawn between these teeth, as produced with formed cutters, and those which are generated, and which depart from the true involute over a greater or less distance. The various systems in use, and the modifications they entail, with the formulæ employed, are stated. The difference between the strict involute and the octoid form, on the basis of which the bevel gear generating machines operate, is explained. All the tooth elements and proportions, with copious tables, are given in this and section II. Section III, on speeds and powers, is an exhaustive one, occupying over 50 pages. It deals with gear trains, but the greater portion treats of the strength of teeth, based on the Lewis formula and its modifications. Factors of safety, the strength of shrouded gears, the wear of teeth, and hardness are treated, with speeds, powers and gear efficiency. Data are adduced to show that the recent hot rolled gears are superior in strength and hardness to those produced by cutting. The chapter is valuable for the collection of data and rules introduced, but it also teems with statements and suggestions which give rise to trains of thought that lie outside commonly received views, and leave the impression that we even yet know very little respecting the behaviour of gears and those things that make for their efficiency. Section IV, giving proportions for the various parts of the several gears, includes keys and force fits. Section V, bevel gears, gives formulæ for blanks and tables, Section VI, on worm gears, deals with a subject of some difficulty in 36 pages. It is almost entirely a

compilation, in which the numerous problems that arise are discussed by experts. The kindred matters of helical, and herringbone, and spiral gears occupy Sections VII and VIII. Skew bevel gears, Section IX, is devoted to these gears—an old design and not satisfactory—used only when the distance between the shafts is not great enough to permit of the employment of worm, or spiral gears. This completes the account of wheels that are commonly employed. The remaining sections deal with unusual forms and late developments.

The subject of intermittent gears is usually treated lightly in works of this class. Section X is devoted to it. The next one with elliptical gears, and the methods of cutting their teeth. Epicyclic gear trains has a Section, XII, to itself, with several pages of formulæ. Friction gears, XIII, have lengthy treatment, with the coefficients of friction developed by various combinations of materials, with power transmitting efficiencies, and endurance tests. The recent spiral type of bevel gears, XIV, is illustrated with the Gleason system. The difficult subject of internal gearing is treated in Section XV. The limitations of the involute tooth lead up to an account of the Williams system, in which the teeth of the internal gear are made with straight-line profiles like those of an involute rack, and by the adoption of which the limitations imposed on the ordinary involute gears are much reduced. These are increased strength, durability, ease of machining, reduced cost of manufacture. The work concludes with a section on the new rolled gearing, produced by the moulding process, in which a die roll acts on a heated blank, through timing gears. The advantages of the system are stated, and formulæ for the die rolls are given. The book contains 353 pages and 273 illustrations, mostly clear line drawings, and is not disfigured with blocks from catalogues. In our opinion this will be for some time to come the standard work on gears, of equal value to the men in the office and in the shops.

BOOKS RECEIVED.

Metals and Metallic Compounds. Vol. III. *The Transition Elements.* By ULICK R. EVANS, M.A. London: Edward Arnold and Co. [Price 14*s.* net.]

Metals and Metallic Compounds. Vol. IV. *Metals of the "B" Groups.* By ULICK R. EVANS, M.A. London: Edward Arnold and Co. [Price 18*s.* net.]

Jordon's Tabulated Weights of Iron and Steel Sections and Other Information for the Use of Naval Architects, Shipbuilders and Manufacturers. Edited by Lloyd's Register of Shipping. Eighth edition, revised. London: E. and F. N. Spon, Limited. [Price 15*s.* net.]

Selwyns International Telegraphic Code for the Iron and Steel Trades, including an Abbreviated Non-Ferrous Metal Section. Compiled by W. M. S. SELWYN, F.R.G.S. Glasgow: Selwyn, Limited. [Price 6*l.* 6*s.*]

United States Geological Survey. Mineral Resources of the United States, 1919. Part I. By G. F. LOUGHLIN. I: 29. *Summary of Mineral Production in Foreign Countries,* 1919 *and* 1920. By L. M. JONES. I: 30. *Iron Ore, Pig-Iron and Steel in* 1921. By E. F. BURCHARD and H. W. DAVIS. II: 1. *Fuel Briquets in* 1922. By W. F. MCKENNEY. Washington: Government Printing Office.

United States Geological Survey. Bulletin No. 729. *Oil Shale of the Rocky Mountain Region.* By DEAN E. WINCHESTER. No. 734. *Deposits of Manganese Ore in the Batesville District, Arkansas.* By HUGH D. MISER. *With a Chapter on the Mining and Preparation of the Ores.* By W. R. CRANE. [Price 45 cents.] No. 735—I. *Diamond-Bearing Peridotite in Pike County, Arkansas.* By HUGH D. MISER and C. S. ROSS. No. 735—J. *The Los Burros District, Monterey County, California.* By JAMES M. HILL. No. 751—A. *Continuity of Some Oil-Bearing Sands of Colorado and Wyoming.* By W. T. LEE. Water Supply Paper No. 504. *Surface Water Supply of the United States,* 1919–20. Part IV. *St. Lawrence River Basin.* NATHAN C. GROVER, Chief Hydraulic Engineer. [Price 20 cents.] Washington: Government Printing Office.

United States Geological Survey. Professional Paper No. 131—F. *Revision of the Flora of the Green River Formation with Description of New Species.* By F. H. KNOWLTON. No. 131—G. *Fossil Plants from the Tertiary Lake Beds of South-Central Colorado.* By F. H. Knowlton. No. 131—H. *The Fauna of the So-called Dakota Formation of Northern Central Colorado and its Equivalent in South-eastern Wyoming.* By JOHN B. REESIDE, Junior. Washington: Government Printing Office.

United States Bureau of Standards. Scientific Papers No. 469. *Directive Radio Transmission on a Wave Length of* 10 *Metres.* By FRANCIS W. DUNMORE and FRANCIS H. ENGEL. Washington: Government Printing Office. [Price 10 cents.]

State of Illinois. Department of Registration and Education. Division of the State Water Supply. Bulletin No. 18. *Activated Sludge Studies,* 1920–22. Urbana: State Water Survey Division.

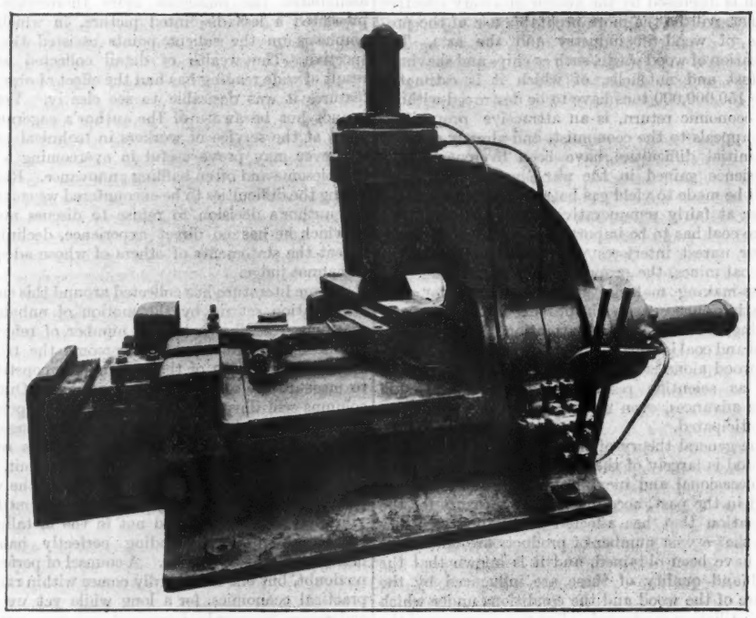
Handbuch der Eisenhüttenkunde. Part I. *Einführung in die Eisenhuttenkunde.* By A. LEDEBUR. Sixth edition. Leipzig: Arthur Felix.

Der Austauschbau und seine pratische Durchführung. By Dr. Ing. OTTO KIENZLE. Berlin: Julius Springer. [Price 8*s.* 1*d.*]

Electric Lift Equipment for Modern Buildings. A Practical Guide to its Selection, Installation, Operation and Maintenance. By RONALD GRIERSON. London: Chapman and Hall, Limited. [Price 15*s.* net.]

MACHINE FOR FIXING SPRING BUCKLES.

CONSTRUCTED BY MESSRS. FIELDING AND PLATT, LIMITED, ENGINEERS, GLOUCESTER.



HYDRAULIC PRESS FOR PUTTING ON SPRING BUCKLES.

THE spring buckling press illustrated above is made by Messrs Fielding and Platt, Limited, Gloucester. It can be used either for putting on or taking off spring buckles. It has a cast iron base of box pattern, extended by a curved arm at the one end of the bed to accommodate two hydraulic cylinders, the one horizontal and the other vertical. Both cylinders are bored out, and gun-metal liners inserted of sufficient dimensions to accommodate the rams throughout the whole lengths of their travels. The vertical ram has a stroke of 8 in. and exerts a total pressure of 30 tons, while the horizontal one gives a load of 40 tons and a ram movement of 12 in. Direct-acting push-back rams and cylinders are fitted in each case for the performance of the return stroke under hydraulic pressure. Gun-metal piston valves operated by hand levers are provided to control the actions of each ram separately.

When the machine is in use to put buckles on springs, the vertical and horizontal rams both work directly on to the buckle, suitable packing pieces being used on the table to carry the buckle. The illustration shows the machine in the operation of stripping buckles from an old spring. The heavy levers shown in action have a foot or pivot, on the outside edge of the machine about which they may be turned. At the other end the levers receive a travel from the horizontal ram. The operation of stripping the spring buckle is carried out at half the length of the levers, so that a total load of twice that given by the ram is obtainable, and consequently a total of 80 tons is available.

MOTOR CAR TAXATION.—Returns issued by the Ministry of Transport show that the total number of motor vehicles, excluding tramcars and trade licences, in respect of which licences were current on May 31 last, was 978,000, this number including 346,000 cars taxed on horse-power, 387,000 cycles, 166,000 commercial goods vehicles, and 79,000 hackney carriages. The total gross receipts for the period December 1, 1922, to May 31, 1923, amounted to 10,930,741*l.*, but this figure is subject to some adjustment with regard to refunds, &c. The average sum received in respect of a whole-year licence was 16*l.* 18*s.* 6*d.* for cars taxed on horse-power, 2*l.* 11*s.* 6*d.* for cycles, 21*l.* 7*s.* for commercial goods vehicles, and 25*l.* 11*s.* 6*d.* for motor hackneys.

THORNYCROFT HYDROPLANE BOAT.—Messrs. John I. Thornycroft and Co., Limited, inform us that one of their 40-ft. C.M.B. type hydroplane boats, named Onward IV, and fitted with a 250-b.h.p. engine, recently crossed the Irish Channel from Holyhead to Kingstown, a distance of over 65 sea miles, in 2 hours 10 minutes, which is about 30 minutes less than the time occupied in the open sea trip by the 25-knot cross-Channel steamers running between Holyhead and Kingstown. The wind at the time was blowing from the North-West with a force 5, which represents a strong sailing breeze, and the trip is certainly further evidence of the excellent seagoing qualities of this type of craft, which qualities were fully demonstrated during the war.

STANDARD SPECIFICATIONS FOR SWITCHES, CIRCUIT BREAKERS AND MOTOR STARTERS.—The British Engineering Standards Association has recently issued 13 additional specifications relating to air-break switches and circuit breakers of the totally-enclosed and flame-proof types, and to various types of starters and controllers for electric motors. The switches and circuit breakers are for pressures up to 660 volts, and the specifications include tests of breaking capacity and of flame-proof qualities. All the specifications have been submitted for comment and approval to interested associations of traders and users, as well as to technical societies and Government departments, and those relating to motor starters, while in draft-form, formed the subject of an open discussion at the Institution of Electrical Engineers. As a result of this, many valuable suggestions were received and adopted, while others have been recorded for use in connection with the work of revision which will take place after the specifications have been in use for a year or two. Copies of the specifications can now be obtained from the Publications Department of the British Engineering Standards Association, 28, Victoria-street, S.W. 1: price 1*s.* each.

THE PROFESSIONAL CLASSES AID COUNCIL.—This association which was reconstituted in April, 1921, to carry on and extend the work arising out of the Professional Classes War Relief Council, has issued its second annual report. The council exists to relieve, or assist in relieving, distress among the professional and other highly-educated classes and their dependants, its general aim when giving financial assistance being to enable the recipient to become independent of further help. The council is by no means a mere distributor of donations, and the recipients of assistance are kept in touch with, and helped with, advice. In the course of the year 538 applications were made to the council, but some of these were unsatisfactory and some did not come within the scope of its work. In all 262 cases were advised and 87 were assisted financially. Fifty families received educational assistance during the year, the professions of the parents including a mining and a civil engineer, a schoolmaster, doctor, shipbroker, &c. The council embraces a wide membership and covers most of the professions. Engineering is adequately represented. The income for the year was 5,121*l.* 9*s.* 2*d.*, there being a deficit of 2,212*l.* 15*s.* 1*d.* on the year's working, and the council would be grateful for any assistance.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page* 60.)

Metallurgy Department. (Dr. W. Rosenhain, F.R.S., Superintendent; Messrs. S. L. Archbutt, J. Murdock, Guy Barr, D. Hanson.) *Staff and Equipment.*—While Dr. J. L. Haughton has left the Laboratory to work in Woolwich Arsenal, several additions have been made to the staff, and the third story, originally planned in Sir Julius Wernher's donation, has been added to the building. The new equipment comprises a small Brinell hardness tester, with 1 mm. ball, and a small electrically-driven milling machine, so designed and encased that contamination of the samples for analysis with impurities, unavoidable when samples are taken in an ordinary workshop, need not be feared. There are further a high-class Tinsley potentiometer, a sensitive Moll galvanometer (described by Dr. Moll, of Utrecht, in 1921, before the Physical Society), and an Ajax-Northrup high-frequency induction furnace, capable of melting about 30 lb. of pure iron within an hour. In this furnace the crucible stands, between bodies of zirconia or other refractory substances, in the middle third of a vertical silica tube which is surrounded by a copper coil through which high-frequency currents circulate. Frequencies up to 50,000 cycles per second are obtained with the aid of mercury sparks, quenched in an atmosphere of alcohol, and a special transformer. This furnace, and a smaller one of the same type, as well as the carbon ring electric furnaces, are especially required for the study of ferrous alloys, which now claim special attention. The melting chamber of the modified gas-fired recuperative furnace, sunk below the foundry floor, measures 2¾ ft. by 1½ ft., and can accommodate pots for melting 100-lb. of glass. The new preheating furnace of the rolling mill is gas-fired and gives temperatures up to 1,350 deg. C.

Alloys Research. Light Alloys.—The researches of Dr. Hanson and Miss M. L. V. Gayler show that both the magnesium and the copper silicide (especially the former) play a part in the hardening of duralumin. Some of the aluminium-zinc alloys are in a close analogy to the iron-carbon alloys; they both form a kind of pearlite, but whilst in Al-Zn this transformation can be entirely stopped by quenching, it can never be prevented completely in iron-carbon even by the most rapid quenching. On the other hand, the quenched steel remains unaltered, whilst the Al-Zn alloy first hardens and then softens at ordinary temperatures, owing to the formation of visible crystals under heat evolution.

By the addition of small amounts of nickel to some brittle aluminium-copper alloys, Miss K. Bingham has made these alloys quite ductile, while as regards the burnt aluminium we mentioned last year (see page 85 of our issue of July 21, 1922), it has been found that repeated remelting does not deteriorate aluminium. The continued investigations by Messrs. Archbutt, J. D. Grogan and A. C. Sturney indicate that the brittleness of burnt aluminium is connected with the impurities (silicon, iron, copper), while Mr. Withy and Miss H. Millar have shown that there is less oxygen in aluminium exposed to oxidising conditions than is generally supposed. Bubbling carbon monoxide through molten aluminium did not spoil the metal. The analytical difficulties of the oxygen determination in aluminium have not however quite been overcome, and the real cause of the weakness of burnt aluminium is not clear.

Castings of the Y alloy (aluminium with 4 per cent. of copper, 2 per cent. of nickel, 1½ per cent. of magnesium) in moulds made from machined Acheson graphite (Mr. C. B. Marryat) and forgings of this alloy have given full satisfaction when conducted with careful temperature control; the forging experiments were made in conjunction with Mr. Ricardo. In Al-Zn alloys, containing 18 per cent. of zinc, a surface protection against corrosion can be obtained by suitable heat treatment.

Ferrous Alloys. Pure Iron.—While the light alloys researches continue, a systematic study of ferrous alloys, in the first instance of binary alloys free of carbon, has been successfully initiated on behalf of the Alloys Research Committee. Though these binary alloys may not be of practical importance, their study is indispensable. A new determination of the melting-point of pure iron in an atmosphere of nitrogen yields the figure 1,530 deg. C., somewhat higher than generally assumed. The very pure Armco iron of 99·87 per cent., containing only 0·02 per cent. of carbon, was first used in this work; electrolytic iron can be obtained quite pure and free of carbon, but there is, apart from the carbon difficulty, trouble with atmospheric oxygen, even when the melting is carried on in an atmosphere of nitrogen or argon. The muffles (90 per cent. of china clay and 10 per cent. of alumina), placed inside the carbon ring furnace, are glazed on the outside and unglazed inside; they keep the carbonaceous gases out, even at 1,600 deg. and 1,700 deg. C., but they have to be fired twice (in the raw and in the glazed state), each time for a week, and they are liable to crack. Natural sillimanite (aluminium silicate) has been tried with success. The study of iron-chromium alloys has given some unexpected results. The addition of chromium to iron seems to lower the melting-point, the δ transformation point and the A_3 point, whilst leaving the A_2 unaffected, in the absence of carbon. Chromite crucibles have alone answered in this research, and they can only be used once.

Iron and Oxygen.—The oxygen trouble is of the following nature:—The oxygen or the oxide dissolves in the iron melt which divides into two layers; one of these is probably oxide and it attacks all the crucibles tried, by forming glassy slags with clay or magnesia, or by entering into the pores of chromite, zirconia, &c. Mixtures of magnesia and iron oxide (rouge), even when containing 70 per cent. of iron oxide, will withstand molten iron, but not molten oxide.

Cracking of Steel. Nickel Steel.—The continued observation of specimens of mild steel, exposed to various degrees of stress at a temperaure of 300 deg. C., has not yet revealed failure of any specimen, a fact which tends to indicate that cracking must be due to other causes than stress and temperature. In these experiments Dr. Hanson has loaded small steel strips, like cantilevers, in a solution of caustic soda electrically-heated in a container of heavy steel tubing; the whole apparatus is hermetically sealed, but warning would be given if any strip should break. The effect of mass on the heat treatment of nickel steel is being studied by request of the Admiralty because gears constructed of nickel steel have given trouble. Pieces of nickel steel, ranging in size from 2 in. up to 10 in. thick and in weight from 10 lb. to 550 lb., have been found to behave in the same way when quenched in oil from a temperature above the critical one and subsequently tempered; the rate of cooling in tempering does not appear to be of importance.

Physical Structure of Metals. Hardness. Action of Cutting Tools.—Miss Gayler's work on the heat evolution during plastic deformation has proved very difficult, even with the aid of multiple thermocouples and the Moll galvanometer. There is little progress in that field, therefore, but the X-ray study of the structure of metals has been successfully taken up in conjunction with the X-ray division, as we shall see.

Dr. Rosenhain has co-operated with Mr. Hankins, of the Engineering Department, in designing a new form of hardness tester. In his study of the deformation of mild steel under the action of a cutting took, Mr. Sturney prepares discs of the steel rod to be tested, and lets the cutting tool act on the circumference to depths ranging from 0·01 in. upward. He then cuts the sector of the disc out, plates it with copper for easier polishing, and projects the cut on paper for convenient examination.

Minor Metals, Cadmium, Beryllium.—Dr. Hanson, Mr. Marryat and Mr. C. H. M. Jenkins have obtained soft cadmium-copper bronzes which can be rolled. Among the metals of minor importance, studied for possible utilisation and other reasons, is beryllium, which Mr. A. C. Vivian has, for the first time, obtained in lumps sufficiently large for Brinell tests. These give a hardness of 160 and more (like a 0·4 carbon steel) and a density of 1·95. The metal is prepared by electrolysing a fused mixture of the double fluorides of beryllium, sodium and barium. As the beryllium melts, at 1,280 deg. C., the bath has to be kept at 1,300 deg. The Acheson graphite crucible serves as anode, and an iron rod, just dipping into the bath (the contact electrode of Bunsen), is the cathode, which may be slowly raised, as Rathenau first did in the electrolytic production of calcium. The beryllium deposited turns spongy when the temperature is too low and other conditions are not favourable. The pure metal is as bright as steel and is, like aluminium, protected against corrosion by an invisible film of oxide which prevents its fusing even in hydrogen at ordinary pressure.

Optical Glass.—In the work on optical glass Miss E. Irvine has been able to make large pots by the pressure-casting process. For the viscosity researches, rods of glass are drawn by means of an appliance due to Mr. R. L. Frink and the Laboratory. Previously the rods had been drawn through water-cooled steel vessels at such a rate that they became chilled in the desired shape; Dr. Seligmann, of the Aluminium Plant and Vessels Company, has advantageously replaced the iron by aluminium. Really satisfactory pot materials, which will resist the attack by the molten glass, have not yet been found; pure fused zirconia is still on its trial.

Metallurgical Chemistry. Standardised Steel Samples. (Messrs. J. Murdock, Guy Barr, T. B. Rooney.)—The varied chemical work, such as that on aeronautical fabrics and dopes, does not call for special comment. Very little progress has been made in the preparation of standardised steel samples. No further ingots have been received for sample production, and the sale of the standardised samples, issued jointly with the Iron and Steel Institute, has proved very disappointing.

Physics Department. (Dr. G. W. C. Kaye, Superintendent.)—The staff, weakened by the loss of several members, as we mentioned in our introduction, has been strengthened by the appointment of three junior assistants and by the temporary co-operation of members from other departments.

Heat and General Physics. (Dr. Kaye, Dr. Ezer Griffiths, Messrs. F. H. Schofield and A. H. Davis.)—The volume of routine test work has somewhat diminished, but there has been a considerable demand for special investigations, both officially and privately. A great deal of the work done for the Engineering Committee of the Food Investigation Board and the Department of Scientific and Industrial Research has been noticed in our columns in our reports on the general discussion by the Faraday Society on the "Generation and Utilisation of Cold" (ENGINEERING, October 20, 1922, pages 498 and 508), in which the thermal conductivities of old-established and new materials for heat insulation and thermometer lag were particularly dealt with, and in the article on the "Transmission of Heat by Radiation and Convection" (December 1, page 672). These researches have been partly interrupted by the journey to Australia which Dr. Griffiths undertook on behalf of the Food Board in the beginning of this year.

Comparison of High-Temperature Scales.—An inter-comparison between the high-temperature scales of the Nela Research Laboratory of the General Electric Company, at Cleveland, and of Teddington had been suggested, because the pre-war international agreement between Teddington, the Reichsanstalt and the Bureau of Standards extended only to 1,100 deg. C. High temperature measurements are not difficult, but the standardisation of the instruments, based on Wien's law of the intensity of the radiation in the visible spectrum, is laborious. The calibration is effected by determining the melting-point of some refractory metal (generally gold or palladium), under black-body conditions and interpolating and extrapolating by means of rotating sectors of measured apertures. The intermediate standard optical pyrometers of the disappearing filament type have been described on other occasions. At Teddington a small kink is made at the apex of the hair-pin filament in order to give the observer a fixed point for his comparison (see ENGINEERING, July 28, 1922, page 121); these filaments are not weakened by the vibrations which affected the kinked heavy-fork Nela filaments.

For the extension of the scale to higher temperatures a series of sectors has been constructed, the radial slots in which reduce the energy transmitted

in steps from unit value to 0·749, 0·498, &c., finally down to 0·00575, thus admitting of measuring temperatures up to 3,300 deg. C. absolute. With the smallest sector used, the disc, 14-in. diameter, running at 3,000 r.p.m., has two apertures, each of 1 deg. of arc; some of the discs have six apertures, but the number is kept low to avoid diffraction troubles. The intercomparison is made with the aid of special tungsten lamps, the apparent filament temperatures corresponding to a series of currents being determined. Although the radiation from one object at 3,300 deg. C. absolute is compared with that from another object at 1,828 deg. (the melting point of palladium), no colour matching difficulties should be experienced.

The discrepancies between the Teddington values and the Nela values being slightly greater than expected, the palladium and gold and also the ruby glass used at Teddington were sent to America. It would appear, however, that the effective wavelength of the ruby glass needed a correction (from 0·66 μ to 0·665 μ), and that the ratio of the blackbody radiations of gold and of palladium requires further investigation.

Physical Constants of Metals.—The question of the thermal constants of pure metals has particularly arisen in connection with the work for the British Non-Ferrous Metals Research Association. An inquiry into the more or less accepted so-called constants has once more revealed the uncertainty of some data and the general scarcity of reliable determinations, and it is proposed to study in the first instance latent heat of fusion, specific heat and thermal conductivity at high temperatures. This inquiry is to be started with materials which may be commercially regarded as very pure, under the assumption that the effect of small impurities will not be important in the case of thermal constants, with the possible exception of certain specific heats. A novel type of apparatus has also been evolved for the determination of the latent heat of liquids at high boiling points. The liquid is boiled at a steady rate and the vapour is condensed in a calorimeter operating on the continuous flow system; the heat required to vaporise the liquid and that liberated by the condensation are determined independently. The apparatus is very convenient for oil testing at temperatures up to 380 deg. C.

Transformer Oil. Hot Pipe Insulation.—The apparatus for determining the cooling power of oils used in transformers was mentioned last year. The full-scale apparatus, since constructed, consists of two vertical pipes, 4 ft. high, cross-connected by large pipes so as to form a rectangular conduit. The vertical pipes are of unequal diameters; the pipe of smaller diameter is heated by an electric coil, the other larger pipe is cooled by a coil carrying cold water. Convection currents of the oil are maintained in this way, and the velocity of the oil, its temperature at entering and leaving the hot pipe, the heat dissipation and temperature of the heating coil are observed together with the water and air temperatures. The composite laggings which have been tested for very hot pipes at 1,000 deg. F. consist of magnesia (mainly hydrated magnesium carbonate). This, however, is not applied directly to the pipe, as it would deteriorate by contact with a pipe nearly at red heat; some protective layer is interposed, and a coating of a hard-setting plaster is applied to the outer surface. The pipe under investigation is closed at both ends and is heated internally by a nichrome coil wound on a cylinder co-axial with the pipe; thermocouples are inserted to different depths in the lagging. The materials are tested separately and in various combinations, so as to allow of calculating the insulating power of any combination.

Metallic Thermionic Valves. (Dr. Kaye, Mr. I. Backhurst.)—The softening of the glass consequent upon the heat evolution by large currents limits the capacity of valves for radiotelegraphy provided with glass bulbs and has already suggested the use of metallic bulbs, which can safely be water-cooled if running too hot. But metals occlude more gas than glass and quartz, and the gas liberation continues even after long heating and evacuating. Aluminium, Dr. Kaye finds bad in this respect, at any rate, when so combined with glass that high temperatures are ruled out. When tungsten filaments are used in the valves, moreover, mercury pumps are unsuitable, because the residual mercury vapour attacks the tungsten, even in the presence of liquid-air traps. The Gaede molecular pump would be the best to attain the high vacua required in valves; but this pump is delicate and needs much attention. Dr. Kaye has hence modified the mercury diffusion pump into a mercury vapour-jet pump (of the injector type) which is worked in series with a condensation pump. One of these pumps was shown in operation on the inspection day.

Photo-electric Cells.—The relative sensitivity of photo-electric cells to radiations of various wave lengths is investigated with the aid of cells containing an active electrode, rubidium or potassium, the other electrode being platinum. The cell is most sensitive to light of about 5,000 Å.U. (green); one candle at 1 m. distance produced a corrent of $7{\cdot}7 \times 10^{-10}$ ampere.

Thermometry Division. (Mr. W. F. Higgins.)—This division now has its quarters in the Victoria House. The numbers of class A and class B thermometers tested have slightly diminished; dial thermometers of medium range continue to behave well; high-range dial thermometers have not yet been submitted. The total number of clinical thermometers tested in the year was 782,743; in the early part of the year they were submitted at the rate of 90,000 thermometers per month. Cold storage thermometers are watched in a box, of 2 ft. cube, which is cooled down to — 30 deg. C. by the ammonia coil of the refrigerating plant presented by Messrs. J. and E. Hall, of Dartford. High-grade resistance thermometers are standardised with the aid of the double bridge, due to Mr. F. E. Smith.

Radiology Division. (Dr. Kaye, Dr. E. A. Owen, Miss P. K. Bowes, Miss B. Naylor, Mr. G. D. Preston).—Messrs. Watson and Sons have presented the Laboratory with a 200,000-volt X-ray outfit, complete with kenotron, rotary converter and gas interrupter.

Radium Testing. Luminous Compounds.—The number of radium samples submitted has somewhat decreased, namely, to 102. They arrive in flat or needle-shaped containers of platinum or silver, sealed by soldering, and this soldering is not infrequently found to be leaky. A correction of the activity found is further needed owing to the absorption of the radiation by the container walls; with glass walls, 1 mm. thick, the correction amounts to about 1 per cent., but it may rise to 2·5 per cent.

An improvement has taken place in the luminous compounds submitted. They contain 4 milligrammes of radium compound (equivalent to 1 milligramme of radium) per gramme of zinc sulphide; the two ingredients are best kept apart until wanted and are then mixed in a neat little tubular apparatus devised by Dr. Owen. The radium salt is placed in a small glass tube which is provided with a lateral stopper; into the open end fits another tube containing the zinc sulphide, this tube being drawn out to a sealed point; a file cut is made in the drawn-out end, and a wire attached to the tip of this end. This wire is taken through the stopper; when the two salts are to be mixed, the wire is pulled and the tip is broken off. All the radium work is done in a separate chamber.

X-Ray Intensity.—The examination of Sabouraud pastilles of barium-platinocyanide with a provisional "N.P.L. Standard dose" is now a routine test; the change of colour is measured by means of a tintometer, and the indications of the pastille, whether with unfiltered radiations (mostly used so far) or filtered radiations, are considered reliable, which does not mean, however, that the biological effect will correspond to the change of colour; that is a complex question. The Fürstenau intensimeter, which depends upon the change of resistance of selenium by the action of X-rays, has been found unreliable owing to the fatigue of selenium; the instrument is useful, however, as an indicator.

Sphere-Gap Voltmeter. High-Tension Conductors.—Needle-gap high-tension voltmeters being too much dependent upon the humidity of the atmosphere and the form and frequency of the volt wave, sphere-gap voltmeters are alone used, but their scale is close. The spheres should therefore be approached to one another very gradually, but they should also be separated again immediately after the first spark temporarily breaks down the insulation. For this reason Dr. Owen makes the movable sphere, sliding in a stand, push a vernier with it, but snap back immediately through the action of a spring and a cam on the handle which he turns. The high-tension conductors are either provided with an earthed caging of wire gauze or with heavy insulation; the No. 16 copper wire is surrounded by 1 in. of pure rubber, covered with an outer layer of hard rubber; all sharp bends are avoided.

X-Ray Protection.—Dr. Kaye represents the Laboratory on the X-ray and Radium Protection Committee which inspects X-ray installations with the aid of portable apparatus, advises on installations and investigates problems arising, at Teddington. It has been found, for instance, that the density of lead-rubber gloves and glass is by no means a safe indicator of their ray-stopping power. This power is, as we explained last year (July 28, pages 121 and 122), expressed in the equivalent lead thickness; a lead rubber of a density 3·81 had a lead equivalent of 0·33 per millimetre thickness of material, whilst a lead glass of density 3·88 had a lead value of 0·17 only. The effect of the pressure used in the manufacture of rubber goods is one of the factors to be considered. As regards concrete, brick, stone, wood, &c., there is no definite relation between density and absorption of X-rays.

X-Ray Intensity.—In X-ray work the current is generally measured because it is assumed to be proportional to the intensity of the rays emitted; operating a Coolidge tube on an induction coil outfit, at 60 kilovolts, however, Dr. Owen and Miss Bowes found, contrary to other observations, that the intensity of the rays was not proportional to the mean current at constant potential in this case. They therefore made comparative experiments by joining a Coolidge tube and a gas tube either to a coil, the current of which was interrupted 50 times per second by a mercury-vapour jet, or to a transformer at 50 cycles; the current was measured by a Duddell oscillograph, the volts were measured by a Taylor-Jones electrostatic oscillograph. Plotting the ionisation produced by the rays against the mean current, they confirmed their previous observation of proportionality in three of the four cases, but not in the fourth of the Coolidge tube and coil; with increasing currents the intensity of the X-rays tended rapidly to a maximum limit, so that with large currents the Coolidge tube, on coil circuits, gave softer rays than when worked from a transformer at the same potential and softer rays also than the gas tube gave in both cases. On the coil discharge the high-voltage peak, which alone produces hard rays, lasted only a fifth of the time between make and break, whilst the current loop extended fairly over the whole of that period. The intensity of the radiation would always appear to be roughly proportional to the mean current, as long as maximum current and maximum potential are in phase.

(To be continued.)

MANUFACTURE OF NON-FERROUS METALS IN THE UNITED STATES.—Census figures for 1921, says *The Iron Age*, New York, show 911 establishments with 39,830 wage-earners engaged in the production of brass, bronze, copper and allied products. This is a falling-off of nearly 50 per cent. in wage-earners from the returns of the 1919 census, while the reduction in value of products from 482,313,000 dols. to 214,904,000 dols. is considerably more than one-half. What strikes us in this paragraph from our American contemporary is the small number of wage-earners stated.

MINE RESCUE WORK IN ARIZONA.—The Globe-Miami (Arizona) District Mine Rescue and First Aid Association is maintained by the mining companies in the districts, and each company contributes to the organisation's support in proportion to the total number of men on the pay roll. A central station, between Globe and Miami, has been established and a truck with 10 sets of 2-hour self-contained breathing apparatus and the necessary accessories is always in readiness to respond to a call to any of the mines in the district. Besides being in readiness for emergency work, the station employees train men in the use of mine-rescue apparatus and in first aid to the injured at the mines of the association. The Globe-Miami Mine Rescue Organisation has been developed to a high point of efficiency and is one of the best in the country. The three largest mines of the district each maintain a crew of 15 men trained in the use of breathing apparatus, and other mines keep crews of five men each. Serial 2,473, which contains a detailed account of mine-rescue manœuvres recently conducted by the Globe-Miami organisation, may be obtained from the Department of the Interior, Bureau of Mines, Washington.

CLYDE MARINE OIL ENGINES.*

By Professor A. L. MELLANBY, D.Sc., Member of Council.

THE application of the heavy-oil engine to ship propulsion involves problems which can only be dealt with in a satisfactory fashion when a wide experience of marine conditions is available, and the recent rapid progress in the development of marine oil engines dates from the time when their manufacture was taken up in centres which already had an extended experience of the earlier steam installations. While the large sizes called for by present-day requirements must involve the use of heavy production plant and, in a measure, place firms with such plant in a favourable position, it is becoming more apparent that the use of the oil engine as the primary power introduces a series of special problems which only those with marine experience are in a position to solve. Thus the absence of boiler plant makes it necessary to review the cargo handling plant, steering gear, ship's heating and other services; while the oil engine itself makes use of a number of auxiliary pumps and fittings, all of which must meet the requirements of marine conditions, not the least important of which is absolute reliability.

During the period when oil-engine manufacturers tendered for the main engine alone, there remained a number of smaller parts, amounting to about 30 per cent. of the engine value, for which the marine engine firms were best fitted to take responsibility. It was, however, only natural, that the tendency should be towards a unification of the interests involved, and the initial experience of those intimately connected with the development stage of the oil engine being available by alliance or licence, the marine engineering firms now deal with the whole installation. The engines passing into service at the present time must be regarded as forming the first phase of the application of the oil engine to sea conditions, and are, therefore, of standard design, except where necessary modifications have been made to suit particular circumstances. With installations of this type coming into use in a routine manner—as a result of the confidence gained by this experience—the marine engineers' appreciation of the importance of higher powers, combined with the relatively reduced bulk and weight, is leading to developments of less orthodox designs, in which, largely by the adoption of the double-acting principle, better use is made of the mass of the material involved. There are several indications that there is no lack of initiative in this direction in the Clyde area, and examples of such developments will be given in a later part of this paper.

Tonnage Regulations.—While any reduction in the engine-room sizes leaves more space for cargo or, alternatively, permits the use of finer lines and higher speeds, the position is somewhat confused by the incidence of the tonnage regulations, which may, due to an unfortunate break in their continuity, actually penalise the ship with a small engine-room. These regulations, which are British in origin, are now universally accepted for the estimation of harbour dues, and their reconsideration is, therefore, a question of high politics. As the geared turbine ship may be occasionally placed in the same position, there is a growing body of opinion as to the desirability of revision and some little sign of movement among the shipping interests towards a review of the position. The question of engine weight is involved with that of bulk in the determination of cargo capacity, although, depending on the trade, there are wide variations in the density of cargoes. In considering the application of oil engines, it is necessary, in this connection, to deal with the gross weight of the installation plus the weight of fuel required to carry the ship to its destination. It is in the second of these factors that the main advantage of the oil engine is to be found, for not only is the weight of fuel used only a fraction of that necessary with steam, so that costs are reduced, but this reduced fuel quantity permits also a corresponding increase in the cargo carried.

Lubrication Problems.—In these days when the properties of space excite discussion before learned societies, it may appear unnecessary to note that a spirit level conveys no permanent indication of the positions which a marine engine may be called upon to adopt. It is, however, the appreciation of this point which often produces the most fruitful results when a critical examination is made of new designs of marine power plant. The condition implies possibilities of air locks, or their equivalent, in pipe systems conveying fuel or water, which, in the latter instance, may readily result in the cylinder combustion surfaces becoming uncovered. It calls for special attention to gravity flow systems which may on occasion find reason to flow in the wrong direction, as, for example, in forced lubrication return pipes, and produces quite important limitations in the application of that important feature of modern machinery, the ring-oiled bearing. In Fig. 1 is illustrated the simple nature of such a difficulty, and one which was sufficient to earn a bad reputation for more than a dozen similarly-designed engines. Here it will be noticed that the bedplate of a multi-cylinder auxiliary engine was cast in two box-sections, one of which included the well for the forced lubrication pump. Each box-section was complete in itself and the oil returning to the well from the opposite end of the bedplate was conveyed through an external pipe A. It was only after repeated failures in the forced lubrication pressure and consequent shutting down of the plant that it was realised that by fitting pipe A off the centre line the remote end of the bedplate trapped the drainage oil on occasions when this pipe was elevated. The proportions of the parts were also such that no excess quantity of oil which the well might carry could compensate for this even with only 10 deg. of list on the ship. The cure in this instance was found in the duplication, at B, of the external pipe.

While the fault just described was associated with the use of forced lubrication, and in an auxiliary engine rather than with any principle of the oil engine, it may be taken that this type of lubrication is already in use in corresponding steam auxiliaries. The consequent reduction in onerous supervision and overhauling had led to its almost universal adoption in the modern main propelling oil engine. Indeed, with the increased number of working parts arising from the use of six or eight-cylinder units it is probable that no other system would give satisfactory service.

The use of a separate crosshead has been dictated by the necessity for relieving the cylinder walls from the

Fig. 1.

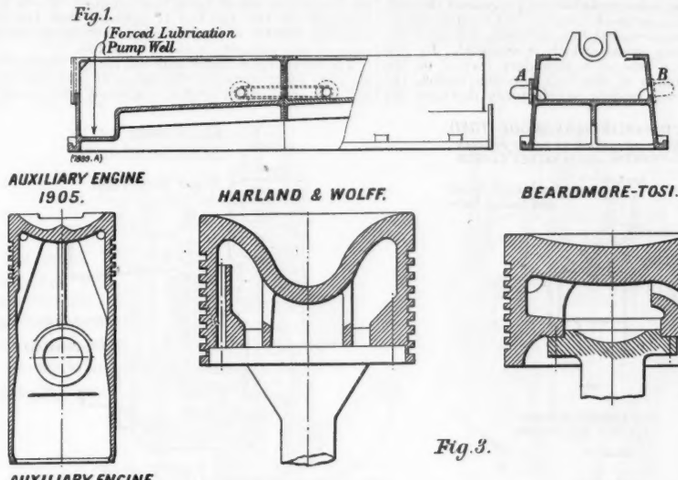


Fig. 2. RESULTS OF A SERIES OF TESTS ON A FOUR-STROKE CYCLE AIR-INJECTION ENGINE.

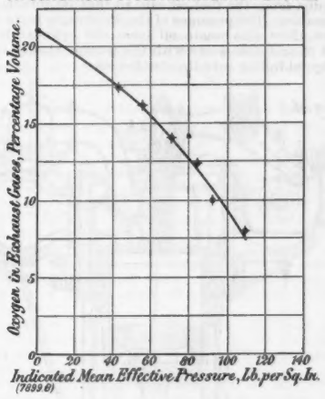


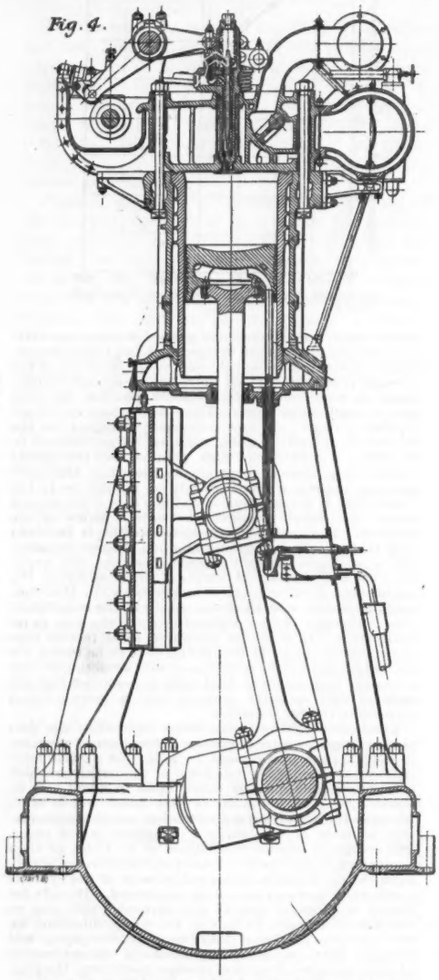
TABLE.

	FOUR-STROKE CYCLE.			TWO-STROKE CYCLE.			
Design	Burmeister and Wain	Messrs. North British Diesel Engine Works, Ltd.	Beardmore-Tosi	Sulzer	Messrs. North British Diesel Engine Works, Ltd.	Scott-Still	Camellaird-Fullagar
Clyde builders	Messrs. Harland and Wolff and Kincaid		Messrs. Beardmore	Messrs. Brown, Denny, Fairfield, Stephen, Weir		Messrs. Scott	Messrs. Brown, Rowan, Dunsmuir
Fuel injection	Air	Air	Air	Air	Air	Mechanical	Air
Fuel duration control	When required	No.	Yes	Yes	Yes	Automatic Yes—automatic	Yes
Crankshaft	Various	Built	Solid-forged	Solid-forged	Semi-built	Semi-built	solid forged
Crank-case lubrication	Forced	Forced	Forced	Forced	Forced	Forced	Forced
Cylinder lubrication clear of crank-case	Yes	Yes	Yes	No.	Yes	Yes	No
Explosion loads thro'	Steel Tie-bolts	Steel Tie-bolts	Cast-iron columns	Cast-iron columns	Cast-iron columns	Cast-iron columns	Working parts only (steel)
Piston cooling medium	Fresh water or oil	Salt water	Fresh water	Salt water	Fresh water	Steam	Fresh water
Piston cooling pipes	Telescopic	Jet system	Jet system	Jet system	Telescopic	None	Telescopic
Piston cooling pressure, lb. per sq. in.	10·15	36	18	30	30	—	30
Manœuvring servo-motor	Air or electric	Air	Electric	Air	Hand	Hand or oil	Air
Starting air pressure, lb. per sq. in.	350	350	500	1,000 at bottles	350	Steam—150	400
Blast air pressure, lb. per sq. in.	850–900	1,000	1,000	800–1,000	900	—	1,000
Air compressor stages	3.–Differential	3.–Differential	3.–Differential	3.–Differential	3.–Differential	—	4.–Differential
Thrust block	Michell	Michell	Michell	Michell	Michell	Michell	Multi-collar
Crosshead slipper	Single or Double	Single	Single	Four faces	Single	Four faces	Double, and with side faces
Camshaft drive	Spur	Skew	Skew	Skew	None	None	Skew and bevel
Fly-wheel	Aft or forward	Aft	Aft	Aft	Turning wheel only	Aft	None

* Paper read before the Institution of Mechanical Engineers at Glasgow, June 27, 1923.

load due to the obliquity of the connecting rod and, as a result, the piston of the four-stroke cycle engine has been shortened from the trunk type to the length required to carry the necessary piston rings only. Thus it has been possible to arrange a diaphragm plate, separating the lower end of the cylinder from the crosshead, and carrying a simple gland for the piston rod. Thus everything is enclosed up to the crossheads, and a complete forced lubrication system to all working parts is possible. The grade of oil required for piston lubrication is generally different from that suitable for continuous service in the forced lubrication system; and, in addition, oil dropping from the pistons may be heavily carbonised and may contain dirt from the fuel-oil ash, so that its further use is undesirable. The presence of the diaphragm plate thus serves to allow this waste oil from the cylinder to be disposed of and does away with the trouble that is often caused by oil falling into the crank-case.

Fig. 4.



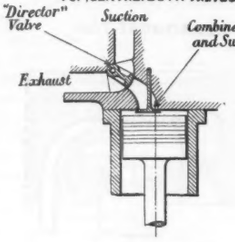
The cylinder sizes now in general use call for pistons with a double crown through which a cooling medium can circulate. This medium, oil or water, is conveyed to and from the piston by a development of a telescopic pipe arrangement. Maintenance of this pipe system has often been found to be fairly heavy, but, where the diaphragm plate mentioned above is included in the design moderate leakage of sea water, when used for cooling, presents no special difficulties, and the engine can remain on duty until port is reached.

In the two-stroke cycle engine the introduction of the crosshead does not afford the same opportunity of shortening the piston, as the long skirt design is still necessary to cover the ports in the cylinder walls. Isolation of the cylinder and piston from the crank-case similar to that obtained in the four-stroke cycle engine, could only be obtained at the expense of a fair increase in overall height and, in consequence, such isolation is not attempted. In a measure the dangers from water leakages are here countered by the use of a fresh-water system for piston cooling. Should leakage occur it can be dealt with by attention to the oil drain tank, since little or no harm will result from the contact of the oil and fresh water, although an emulsion would form if salt water were used.

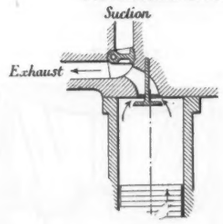
Starting and Manœuvring.—From the time the ropes are cast off from the fitting out jetty, the safety of the ship depends upon nothing so much as the immediate response to all manœvring orders. The starting and manœuvring qualities of the engine take on, therefore, an importance which can scarcely be overestimated. These orders may follow each other in rapid succession or, on occasion, be separated by a month or more. For the first condition it is essential to eliminate any involved system of control or heavy manual operations, and for the second the engine must possess in an unusual degree the ability to remain on service when the working parts commence to get out of adjustment. Again, while the longer running periods are associated with steady loads, at or about full power, there are also occasions when relatively low speeds are called for and to which nothing in land practice closely corresponds. It is probably true that some of the earlier installations progressed through the Suez Canal in a series of "starts," but a better appreciation of the requirements has, however, indicated the range of operating speeds which is essential. By the introduction, as a rule, of a secondary control on the duration and timing of the fuel injection period, the modern engine will operate satisfactorily down to the limit set by the flywheel effect. This limiting condition is attained when the energy of rotation is so small that the compression stroke of the cylinder next on turn for firing brings the engine to rest. For such a state of affairs the problem becomes almost entirely one of flywheel dimensions, and it should be noted that, where a flywheel is found to have a ponderous appearance, the limitations imposed on the diameter, by the position of the engine in the ship, prevent the attainment of peripheral speeds common in land practice. In passing, it is perhaps of interest to note that the presence of a flywheel in the system formed by the tunnel shafting, with propeller at one end and engine masses at the other, has so reduced the critical speed of torsional oscillation that special adjustments may be necessary to avoid this coming within or near to the operating range of speeds.

Fig. 5. DIRECTOR VALVE (BEARDMORE-TOSI).

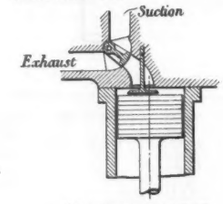
(a) BEGINNING OF FIRING STROKE, PISTON TOP CENTRE. BOTH VALVES CLOSED.



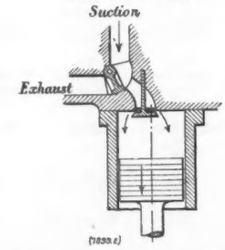
(b) EXHAUST STROKE PISTON ASCENDING.



(c) END OF EXHAUST STROKE, PISTON ON TOP CENTRE. "DIRECTOR VALVE" CLOSES CYLINDER PASSAGE. COMBINED SUCTION AND EXHAUST VALVE STILL OPEN.



(d) SUCTION STROKE. PISTON DESCENDING.

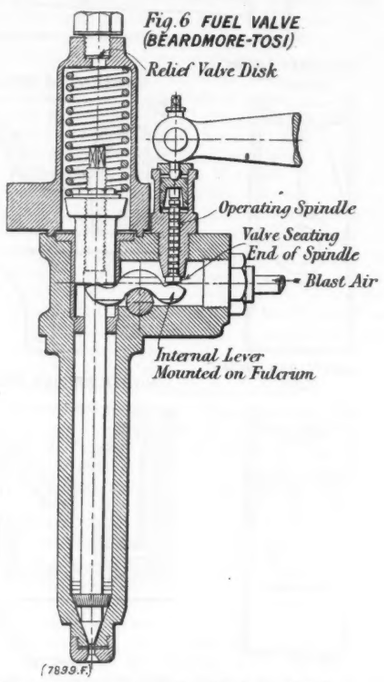


(7839.c)

As the position in which the engine may come to rest is quite indefinite, the starting air must at all times be able to operate effectively on one or more cylinders. This, then, is one of the reasons for the number of cylinders to be found in a marine Diesel installation and questions of power output per cylinder are often of secondary importance. The problem of starting thus dictates a minimum of six cylinders for a four-stroke and four cylinders for a two-stroke cycle engine. As reversal orders are generally given when the ship has a certain amount of forward motion of anything up to full speed, there is a negative torque from the propeller action which entails a wide margin in the capacity of the air starting system over that possible if the engine could be started light. The requirements of Lloyd's call for a demonstration of 12 successive reversals under such moving conditions, without use being made of auxiliary compressing plant, and the storage air capacity in general use would give about twice that number. From figures obtained on the test-bed it appears that the corresponding number of starts, for light conditions, from the same storage capacity is about 60 to 100.

The reversing arrangements call for the duplication of the cam gears operating the valves of both the starting air and combustion cycles, combined with means for releasing the gases from the cylinders which have come to rest during the combustion stroke and in which, consequently, reversal might lead to excessive pressures. It is in this connection that the greatest variety of detail is found when the designs of different manufacturers are contrasted. While discussion of the different principles cannot be entered into here, it may be noted that a servo-motor of some type is, in general, used to facilitate the rapid performance of orders, but the duties of this unit may vary quite widely.

Fig. 6 FUEL VALVE (BEARDMORE-TOSI)



(7839.F.)

Power Rating.—The same general principles are applicable to all the engines under consideration, with only differences arising from such details as the use or absence of blast air for fuel injection. The pressure attained at the end of compression is dictated by the necessity for ensuring self-ignition of the fuel charge, and, with the exception of a few cases where heat is deliberately applied to the incoming cylinder air charge, it is generally in the neighbourhood of 500 lb. per square inch. Consideration regarding strength of parts would, in any case, dissuade the designer from permitting the combustion pressure to rise much above this figure and, in practice, Lloyd's, in the interest of the crankshaft, require this pressure to be brought below the design figure before the ship goes on service. The propeller torque changes with the variation in cleanliness of the ship's bottom, the cargo carried and the weather, and if the speed is to be maintained it is essential to have a margin on the working mean effective pressure in the cylinder. The limiting value is largely dependent on the oxygen content of the cylinder air charge, and with modern scavenging arrangements there is now little difference in this respect between the four-stroke and the two-stroke cycle engines.

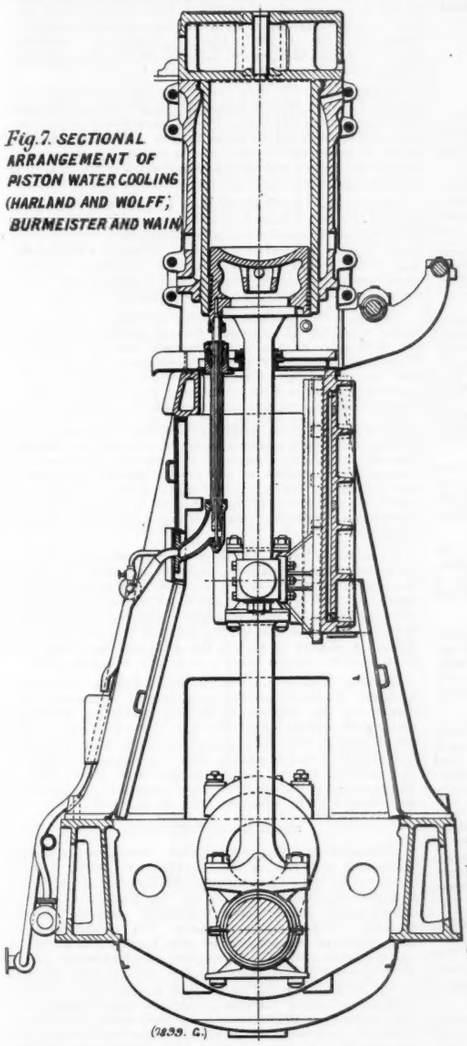
So far as engines with low compression and a heated scavenging charge are concerned, it should be noted that the heating of the air must result in some diminution of the charge weight. Within the limits of the information at present available it would appear, however, that this factor does not exercise a sufficient influence to cause any important departure from the relationship shown in Fig. 2. Here the results of a series of tests, made on a four-stroke cycle air-injection engine in the laboratory of the Royal Technical College by the author and his colleague, Professor T. Gray, are plotted to show the connection between the oxygen remaining in the cylinder after combustion and the mean effective pressure in the cylinder. The slope of the curve shows that as the oxygen content of the gases is reduced the rate of increase of mean effective pressure diminishes. By producing the curve, it is suggested that a limiting mean effective pressure of about 140 lb. per square inch would be

associated with complete combustion of the oxygen. Experience with this engine shows that any close approximation to such a figure can only be attained by careful attention to a series of settings, and it is quite unlikely that any lengthy run with such pressures could be made. It is, therefore, suggested that trials showing mean effective pressures in the cylinder of values approaching to this should be received with suspicion, unless a definite system of supercharging is in use. Experience points to a practical value of about 125 lb. per square inch for an overload, and as on shipboard the usual figure on trial is about 100 lb. per square inch it can be seen that the margin is about 25 per cent.

Clyde Engines : General Notes.—Before describing local engines in detail it is proposed to make a few general remarks upon some of the main features of the various designs. The trend of local practice is brought out in the table page 95, where the important characteristics of the engine have been brought together. The popular engine would still appear to operate with air injection by means of a fuel valve with hand control over the duration of injection. Thus, there is little sign that the mechanical injection principle is gaining ground, although there must be every inducement to eliminate the continuous operation of the blast air compressor, providing no counteracting disadvantages were involved. Marine practice has, in the past, made large use of built-up crankshafts, and the preponderance of solid forged shafts shown in the table is probably merely a passing phase. It is dictated by the interaction of present-day practice in piston and rotational speeds with Lloyd's rules for shaft sizes, the effect of which is to leave little material to carry the shrink stresses between the shaft and webs. In four-stroke cycle engines the Clyde builders have avoided the use of water cooling in the exhaust-valve head, although this cooling is not unknown in other districts. The material for the valve head receives special consideration, and this, combined with thorough cooling of the valve seat, is found to satisfy present-day requirements. Here the specially favourable conditions arising from the use of the combined exhaust inlet valves in the Beardmore-Tosi engine deserve attention. These valves remain off their seats from the commencement of exhaust until the completion of induction, and hence, any carbon gathered during the earlier period is burnt off again by the incoming air so that the valve is always found perfectly clean. In addition, the incoming air cools the valve head to such an extent that regrinding is almost unnecessary. In consequence it has been found satisfactory to dispense with the usual valve cage and to make the valve seat directly on the cylinder head casting.

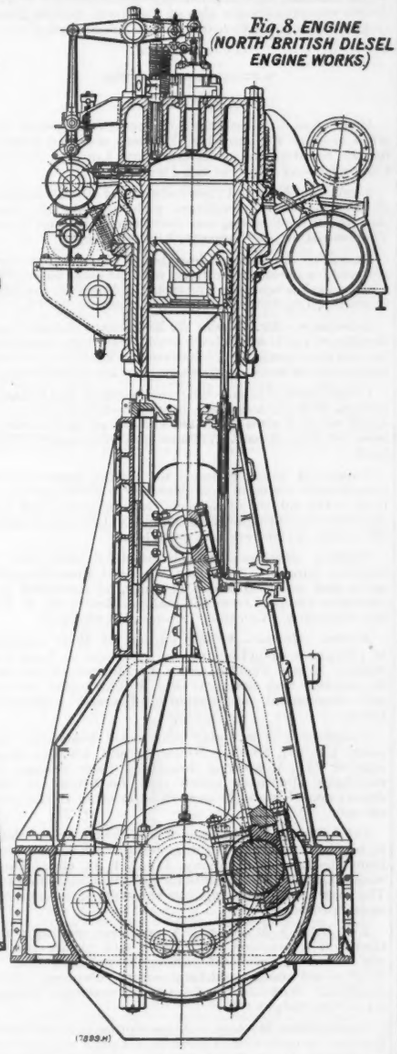
With the exception of the Scott-Still engine, all those tabulated have the cylinder-liners cast separately of simple cylindrical form. Usually the liner is located at its upper end and free to expand downwards, while the explosion loads are taken through the cylinder-jacket. The cylinder head of the four-stroke cycle engine is still a somewhat complicated casting, but this has not prevented the North British Diesel Engine Works from recessing the under surface and thus gaining room to accommodate larger valves. On service this design has proved very satisfactory. In the two-stroke cycle engines the increased value of the heat stresses has resulted in the disappearance of the valve-in-head scavenging arrangement, and the symmetry of the current Sulzer design must give favourable conditions in that part.

Fig. 7. SECTIONAL ARRANGEMENT OF PISTON WATER COOLING (HARLAND AND WOLFF, BURMEISTER AND WAIN



(1839. G.)

Fig. 8. ENGINE (NORTH BRITISH DIESEL ENGINE WORKS.)



(7393.M)

While the pistons are comparatively simple and symmetrical castings, they are at a disadvantage due to the fact that the cooling medium has to reach them through the telescopic pipe system. Here it is the upper surface which requires to be in contact with the cooling fluid, and this is, unfortunately, the part at which any air in the system will lodge. That much can be done through progressive design to ease the conditions is indicated by Fig. 3, page 95. The final form in which the load is carried at an intermediate diameter is probably the most definite step in recent progress towards larger units.

Clyde Engines : Particular Types.—From the preceding remarks it will have been gathered that, at the present time, a large variety of types of the marine Diesel engine are being constructed on the Clyde. The standard four-stroke cycle air injection engines are being made by Messrs. William Beardmore and Co., of Dalmuir, who are manufacturing the "Beardmore-Tosi" type; Messrs. Harland and Wolff and Messrs. Kincaid, who have adopted the Burmeister and Wain system; and the North British Diesel Engine Works, who are developing the single-acting, air-injection engine of their own design. There are also strong supporters of the two-stroke cycle principle. Of the firms building this type of engine there are Messrs. Scott's Shipbuilding and Engineering Company, with the Scott-Still engine; Messrs. William Denny and Brothers; Messrs. A. Stephen and Sons; Messrs. Fairfield Shipbuilding and Engineering Company, with Sulzer licences; Messrs. John Brown and Co., Messrs. David Rowan and Co.; Messrs. Dunsmuir and Jackson, with the Fullagar engine developed by Messrs. Cammel Laird and Co., of Birkenhead; and Messrs. the North British Diesel Engine Company, with the unique double-acting engine of their own design. It will thus be seen that the advocates of the two and four-stroke cycle engines are fairly well balanced, although up to the present time the majority of engines turned out have been of the four-stroke cycle design.

Examples of Four-Stroke Cycle Engines.

In reviewing the work which is at present being undertaken, the pioneering work of Messrs. Barclay Curle and Co. should not be forgotten, as the first Clyde-built ocean-going, full-powered Diesel engine driven vessel was built and engined by them. This was the Jutlandia, completed in 1912 to the order of the East Asiatic Company, of Copenhagen. The engines fitted were of the four-stroke cycle, air-injection type, driving twin screws. Each set of engines consisted of eight cylinders, 20¾ in. diameter by 28½ in. stroke, and on trial they developed 2,500 i.h.p., with a consumption of 0·34 lb. of Scotch shale oil per indicated horse-power hour.

Beardmore-Tosi Diesel Engines.—Although most of the Diesel ships at present in service are comparatively large-sized cargo carriers, fitted with twin screws and destined to sail to distant ports, the relative prices of oil and coal and the arrangements for the distribution of liquid fuel are such that for vessels trading in home waters, or between Britain and the Continent, the Diesel system presents distinct advantages. These advantages were recognised by Messrs. MacAndrews, of Liverpool, who for over one hundred years have been connected with the Anglo-Spanish-Portuguese general fruit and wine shipping trade, and who have now over 20 steamers in operation. It is of interest to note that this firm were among the first shipowners in this country to adopt superheated steam in conjunction with triple-expansion engines, and were the pioneers in this respect for the class of vessel suitable to their trade. Among the advantages of the Diesel engine in connection with the carriage of fruit, or other cargoes likely to deteriorate with rise of temperature, is the elimination of the stokehold and the consequent possibility of ensuring the discharge of the cargo in perfect condition. The economical speed of the class of vessel best suited for this trade is from 10 knots to 11 knots which, in conjunction with the size of ship determined by considerations of the ports with which they trade, makes the single-screw arrangement preferable to that of twin screws. Two vessels of this type—the Pinzon and the Pizarro—have been fitted with Beardmore-Tosi engines and have already given excellent results on service. Each ship is fitted with a set of engines consisting of six cylinders, 24½ in. diameter by 38½ in. stroke, developing 1,250 b.h.p. at 120 r.p.m. The general design of the engine will be seen in Fig. 4, where it will be noticed that, so far as the main parts of the engine are concerned, standard reciprocating marine practice has been followed. As has been found essential with marine Diesel engines, forced lubrication has been adopted for all bearings, the oil to which is supplied by independent motor-driven pumps. Among the special features of the Beardmore-Tosi engines are the method of starting, designed to minimize the quantity of compressed air required, and the various details in the design of the parts connected with the combustion to render cooling particularly even and to minimise the heat stresses. In this connection attention is directed to the cylinder liner, where it will be noticed that spiral ribs are cast on the outer surface in way of the combustion chamber. This ensures a definite direction to the jacket water in this part, and even cooling of the liner is secured where it is subjected to the greatest temperature. The special combined air-inlet and exhaust valve, combined with the director is shown in Fig. 5. Although it would be possible to use only one valve in the cylinder head with this arrangement, two are adopted in order to obtain symmetry of design. It will be noticed that instead of one of these valves being used exclusively to admit the air and the other to discharge the hot exhaust gases, both serve for inlet and both for exhaust. The result is that in each cycle the valves are swept by the cool incoming air, thus keeping them at a moderate temperature and sweeping off any carbon which may have lodged on the faces during the exhaust stroke. Re-grinding of the valves is thus reduced to a minimum, and their comparatively small size and slow motion result in a remarkably silent operating gear. In Fig. 4 will also be noticed the diaphragm plates, fitted with simple glands for the passage of the piston rods, and already referred to under the section on Lubrication. The illustration also shows a light sheet steel manifold pipe, placed immediately above the exhaust pipe and running the whole length of the engine; the air induction passages in each cylinder head are directly connected to this manifold. At each end of it a grid is fitted, and at its centre is another pipe leading to a common chamber at the base of the cylinders. By means of this arrangement the space below the pistons is thoroughly scavenged and, should there be any "blow" past the piston rings, the gases do not pass into the engine-room, but are drawn up into the induction manifold.

The fuel injection valve used on this engine is shown in Fig. 6. The valve is of the needle type, totally enclosed and operated through an internal lever pivoted on a

fulcrum. The spindle that operates the valve is a small ground plunger, the bottom of which has a conical seat which acts as a valve. During the fuel injection period the main valve lever depresses the operating spindle, and the valve face is removed for a short period from its seat. It has been found that any air leakage which might take place while this valve is open is effectively prevented by the ground plunger. No oil leakage whatever takes place, and freedom is ensured from the troubles that so often result from packed gland spindles.

Burmeister and Wain Engines.—Much of the credit for the position attained by the motor ship must be given to Messrs. Burmeister and Wain, of Copenhagen, whose pioneer work has led to the installation of engines of this type in more than 100 vessels. Their licences in this country are Messrs. Harland and Wolff, and the Clyde works of this firm have produced engines which outnumber the combined totals of the remaining local works. Engines of this class first appeared in Messrs. Barclay Curle's ship Jutlandia, mentioned in the early part of this paper. Since then there has been continuous progress in detail, with an advance in cylinder sizes, so that engines with cylinders up to 30-in. bore and 60-in. stroke are now being turned out. A special type of engine, with relatively long stroke has also been produced with a view to the attainment of high propeller efficiency in single-screw vessels, and more recently, a four-stroke cycle engine of the double-acting, type has reached the stage where it may go into production.

The single-acting engine, which is illustrated by Fig. 7, is made to a design which has come to be accepted as practically standard in marine service. The combustion cylinders have the liners, jackets and heads as separate castings. These are carried on a cast-iron structure but long steel bolts take the combusion loads down to the sole plate so that the cast-iron columns have only to provide rigidity to give form to the light steel plating which encloses the working parts. The camshaft is located at the level of the bottom of the cylinders and is moved endways to bring the correct cams into action for the direction of rotation desired. The cam rollers are connected to the valve levers by relatively long rods and are drawn athwartship by links from an auxiliary shaft to permit the necessary movement of the camshaft at reversal. The fuel valve differs from that commonly found in practice since the spindle has a mushroom head and the valve opens downwards into the cylinder. The air starting valve also shows some original features, since, although it is cam operated, no mechanical control has to be provided to put it in or out of action. This feature is attained by a construction which incorporates a small piston and cylinder as part of the valve stem. The result is to shorten the effective length of that part immediately the engine is put on to fuel, so that the cam automatically goes out of action.

To facilitate continuous operation over long periods a special point has been made of providing means for maintaining the correct adjustment of small working parts without stopping the engine, and under certain conditions it is even possible to replace in this fashion such items as air compressor valves.

The large share taken by Messrs. Harland and Wolff in the production of Clyde Diesel engines has been previously mentioned, but it is probable that some actual figures regarding their output may bring to mind, in a more convincing fashion, the part that is now being taken by the Diesel engine in ship propulsion. The best proof of the confidence that is now felt in the Diesel engine would appear to be furnished by a reference to the ships owned by the Glen Line that have been engined by Messrs. Harland and Wolff. Between 1915 and 1919 six boats were fitted with Diesel engines developing a total of 19,200 i.h.p.; and between 1920 and 1922 other six boats were sent to sea fitted with Diesel engines developing a total of 30,400 i.h.p.

North British Diesel Engines.—The North British Diesel Engine Works were founded in 1913 for the purpose of building marine Diesel engines, and are unique in respect of the fact that they are the only works in Great Britain originally built and laid out for the special purpose of making this type of marine engine. During the war they were absorbed in a varied production of war material, which ranged from shells and guns to aeroplane engines, steam turbines and Diesel engines for submarines. Apart from submarine engines, therefore, the firm had no opportunity during that period of fulfilling the purpose for which they were designed. In 1919, when their war contracts were concluded, they were able to devote their attention to the design of Diesel engines for the mercantile marine, and a large number of orders were procured. The engine made at these works is entirely of home design, and no assistance has been obtained from any foreign or other licensor. It is of the four-stroke cycle, single-acting type with air injection, and embodies in its design all the characteristics of the accepted Clyde practice for marine engines of the best class. A sectional view given in Fig. 8 shows that the bedplates, columns, connecting rods, crossheads and crankshafts are all of the characteristic marine type with which the sea-going engineer is familiar. The general construction of the cylinders and framing for their large engines is somewhat different from that adopted in the usual type of Diesel engine. It will be noticed that the cylinders are bolted to an entablature surmounting the guide columns, and that the main stresses are taken by forged steel tie-bolts extending from this entablature to the underside of the bedplate. The guide columns are thus relieved of all vertical stresses, and deal only with the lateral pressure received from the crosshead slippers. The camshaft derives its motion through gearing from the crankshaft, and is well below the top of the cylinder covers. This necessitates the use of short vertical push rods for the operation of the valve levers. Reversal is effected by means of a direct push reversing engine operated by compressed air, and which, through suitable gearing, interposes the reverse cams in place of the ahead cams in a manner usual with this type of engine.

It has been the policy of this firm to standardise their engine sizes, and for this reason it will be found that, in some boats, the injection air-compressors are driven off the main engines, and, in others, separate units are employed. Thus on the Domala, where the maximum shaft horse-power that could be developed by the engine was required, two 400 b.h.p. six-cylinder Diesel sets are employed to drive the compressors. The main engine has thus no accessory pumps of any kind, except the very small ones necessary for lubricating the pistons. In the Dumana, where a slightly less speed is desired, the injection air compressors are driven off the main engines, and auxiliary manœuvring compressors are driven, one by a 250-b.h.p. electric motor, and the other by a 300-b.h.p. six-cylinder Diesel engine. It is worthy of notice that the auxiliary Diesel engines used for driving the air compressors are also of the North British Diesel Engine Company's own design and manufacture.

(To be continued.)

CATALOGUES.

Iron Pipes.—A catalogue of centrifugally-cast iron pipes in stock for immediate delivery is issued monthly by the Stanton Ironworks Company, Limited, Nottingham, who send a copy of the June issue.

Shaft Couplings.—A new edition of their catalogue of flexible shaft couplings, with a table of power, dimensions and prices, has been issued by the British Thomson-Houston Company, Limited, Rugby.

Switches.—A catalogue describing a range of switch gear adapted for various conditions, with tables of dimensions, and prices, has been received from the Foster Engineering Company, Limited, Wimbledon, London, S.W. 19.

Lubricator.—Mr. Charles W. Richardson, Lower Carrs, Stockport, sends a concisely-worded catalogue describing his valveless mechanical lubricator for supplying a forced feed of one or more qualities of oil to any type of engine.

Power Transmission.—Shafting, bearings and housings, pulleys, and toothed gears, in all standard forms and in a full range of sizes are listed and priced in a catalogue received from Messrs. Williams and Womersley, Wakefield.

Pump.—A plunger pump for raising water against considerable heads in quantities up to 9,000 gallons per hour is the subject of a special catalogue received from the Pulsometer Engineering Company, Limited, Reading. The stroke is short and the speed high.

Hauling Machine.—An electrically-driven gear for hauling, winding, &c., with standard interchangeable parts and enclosed roller bearings, is described in a catalogue received from the makers, Messrs. M. B. Wild and Company (Nechells), Limited, Birmingham.

Electric Motors.—A new edition of their catalogue of polyphase induction motors has come to hand from Messrs. Bruce Peebles and Co., Limited, Edinburgh. It contains very complete and well-arranged technical and commercial information and useful explanatory notes.

Telephones.—The Relay Automatic Telephone Company, Limited, Marconi House, Strand, London, send a number of publications describing their systems and telephone apparatus which may be fitted for interdepartmental use only or with connection to the public service.

Oil Filters.—A catalogue of 50 pages quarto, relating to oil filters and lubrication generally, has come to hand from the Lunken Company, Limited, 35, Great Dover-street, London, S.E., agents for American manufacturers. The matter is interesting, but the style is unfortunately rather prolix.

Tile-Making Machines.—A press for making roofing tiles and a machine for making stiff plastic tile bats are shown in two leaf catalogues received from the Brightside Foundry and Engineering Company, Limited. Sheffield. Both are power-driven machines designed for a large output.

Coal-Mining Machine.—A description of a coal-cutting machine in operation is given in a 4-page circular issued by Messrs. Hugh Wood and Co., Limited, Newcastle-on-Tyne, who are agents for the Jeffrey Manufacturing Company, makers of the machine. A two-pronged "pick" (the cutter bit) is also described.

Mining Machines.—A small air-driven hoist easily applied in restricted mineways for hoisting or hauling and a machine for grinding the cutter bits in coal-cutting machines are the subjects of two interesting little catalogues received from the Sullivan Machinery Company, 122, South Michigan-avenue, Chicago, U.S.A.

Packings.—Packings and kindred manufactures in great detail are shown in a new 100-page catalogue issued by the Beldam Packing and Rubber Company, Limited, 29, Gracechurch-street, London, E.C. 3, with sub-divisions for metallic and semi-metallic packing, jointing, heat-retaining covering, hose, belting, &c.

Illuminated Gauge Glass.—An electric light fitting for boiler gauge glasses, with parts for quick attachment is worth attention where any difficulty is found in seeing the water level. A catalogue describing this has been received from Messrs. Ronald Trist and Co., Limited, 12, Clipstone-street, Great Portland-street, London, W.

Ball and Roller Bearings.—A revised and slightly extended edition of their catalogue of ball and roller bearings has been issued by the Hoffman Manufacturing Company, Limited, Chelmsford. It is well arranged for quick reference, contains full dimension and price tables and relevant technical information, and is well printed.

Wireless Apparatus.—A 56-page general catalogue of parts with full particulars and prices and a 20-page book of wiring diagrams are to hand from Messrs. C. F. Elwell, Limited, Craven House, Kingsway, London, W.C. 2. Each of these is marked price 1*s.*, and will be useful to those who fit up apparatus for themselves.

Screw Grinding.—The Precision and Thread Grinder Manufacturing Company, Limited, 1, South Twenty-First-street, Philadelphia, U.S.A., send us a copy of a recently-issued catalogue of their grinding machine, diamond dressing tool and lead screw pitch corrector made by them for grinding screw threads on tools after the hardening and tempering operation.

Oil Engines.—A clear and simply-worded description of the construction of the Fullagar oil engine, especially of the points on which it differs from other two-stroke cycle engines, is given in a 12-page quarto catalogue issued by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. The description refers to the land type of engine.

Lifting Gear.—A new issue of their catalogues by Messrs. Herbert Morris, Limited, Loughborough includes three sections on (1) Worm Gear Pulley Blocks, (2) Portable Jib Cranes, (3) Vertical Boilers. These catalogues are of 4 pages each, and there is also a 2-page issue on the advantages of a general scheme for all lifting and conveying apparatus required in an establishment.

Economiser.—Their economiser for utilising the waste heat of the boiler flues for feed water heating for water-tube boilers is described in a catalogue recently received from Messrs. E. Green and Son, Limited, Wakefield. The construction in sections and in interchangeable parts enables cleaning, repairs and replacements to be very quickly effected with the special tools provided.

Welded Steel Tanks, &c.—Some excellent examples of tanks constructed of steel plates electrically welded are shown in a catalogue received from St. George's Engineers, Limited, Hulme, Manchester. Among them are included large condenser shells, jacketted pans, transformer tanks with circulating piping, stills, wagon bodies and other vessels, many of which are usually cast.

Winding Engines.—Amongst many catalogues of mining machinery recently received, that of the Worsley Mesnes Ironworks, Limited, Wigan, is of interest as containing examples of self-acting checks and safety devices of an entirely mechanical kind. These were referred to recently in our columns in connection with the Mining Exhibition dealt with on page 738 of our last volume.

Mining Appliance.—Pulling out the props in mines is generally a dangerous task, as knocking away the end of the prop may start a fall in the roof. An appliance with chain and rack which the miner can operate from a safe distance is shown in a catalogue received from Messrs. Mathias, Spencer and Sons, Arley-street, Sheffield. A second appliance is shown for gripping the chain and holding it in tension while a new grip is being taken.

Hauling Engine.—The Yorkshire Engine Company, Limited, Sheffield, send a catalogue of a haulage gear driven by air engines with two oscillating cylinders driving the drum shaft through reduction gear. The whole gear is very compact and the parts well protected. Ten standard sizes are made with interchangeable parts—the smallest having 3-in. cylinders and drums 10½-in. diameter by 5½ in. wide; and the largest 12-in. cylinders with drums 27 in. diameter and 20 in. wide.

EXPERIMENTAL BLAST FURNACE.—Details of an entirely successful test run of the experimental blast furnace operated by the Department of the Interior at the North Central experiment station of the Bureau of Mines, Minneapolis, Minn., have just been received by the bureau. This test run marks the culmination of four years of experiment by the Bureau of Mines, in co-operation with the University of Minnesota, in the development of this blast furnace, and the investigators at the Minneapolis station are now in a position to undertake the study of various problems. After blowing in, the furnace was operated as a slagging-type gas producer, until it had reached a steady state thermally and chemically. A series of thermal couples were used to determine the travel of the heat wave up the charge column as the cold material used in filling the furnace gradually acquired heat. When the top temperature indicated that the furnace had reached a steady state, iron ore, without the addition of flux, was charged, and its descent in the furnace was followed by means of gas samples taken from various planes. When the effect of this charge had been dissipated, more of the same size iron ore was charged without any limestone and another set of gas samples was taken. The purpose of these experiments was to obtain a comparison of the gas composition at various planes of the furnace when no reduction was taking place, and when an iron ore burden had been charged. Without changing any of the operating details the physical character of the burden was then changed to a less homogeneous ore size. Several rounds of fine ore were next charged and the reduction at the stock line was found to be greater than when a coarser ore was used. An iron ore burden was charged continuously for several days, approximately 3 tons of grey iron being made per day. Towards the end of the run several tons of spiegeleisen were made from anganiferous iron ore from the Cuyuna Range. Gas samples were taken on this ore, as well as on the iron ore, from five elevations during the operation. The furnace was operated for 12 days and blown out empty and was found to be in good mechanical condition.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

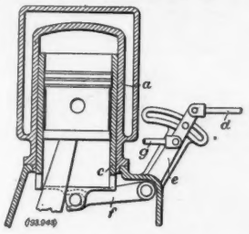
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

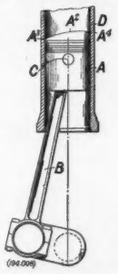
GAS ENGINES, PRproducers, HOLDERS, &c.

193,948. C. A. Vandervell, Acton Vale, Acton. Internal-Combustion Engine Cylinders. (1 *Fig.*) November 29, 1921.—The invention relates to internal-combustion engines, and has for its object to provide a construction which will permit of obtaining a constant compression irrespective of the variations in the amount of mixture admitted into the working cylinder. This object is attained, according to the invention, by lining the interior of the working cylinder *a* with an open-ended sleeve *c*,



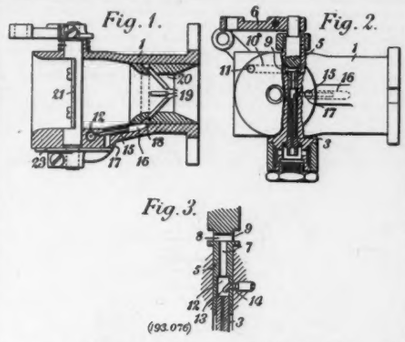
preferably of metal, which is adapted to be longitudinally displaced by means of a control lever *d* and the arms *e* and *f*. The throttle valve and the sleeve are interconnected so that they are operated simultaneously, the interconnection being such that the maximum compression space corresponds to the position of full opening of the throttle valve. In the example illustrated on the drawing, this is effected by means of a link *g* connected to the throttle valve and to the arm *e*. (*Sealed.*)

194,008. Humber, Limited, Stoke, Coventry, J. A. Cole, Coventry, and L. J. Shorter, Coventry. Pistons. (8 *Figs.*) December 10, 1921.—The invention relates to a piston of the kind which has its face so shaped that the fluid pressure upon it sets up a side thrust of the piston on the cylinder wall in the plane of the connecting rod swing. According to the invention, the piston crown is formed with a face of varying contour and is so inclined to the axis of the piston that, when the piston is subjected to fluid pressure, a side thrust is exerted upon it towards the cylinder wall. This side thrust is in the plane of the swing of the connecting rod and is utilised to counteract, to the



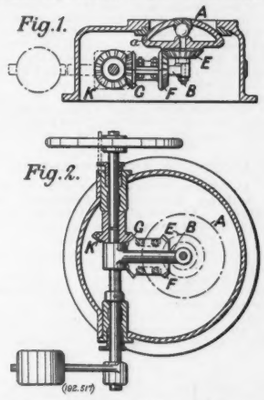
desired extent, the side thrust on the piston due to the angularity of the connecting rod. The piston is designated by the reference letter A, and the direction of inclination of its crown A^2 between the opposite edges A^3, A^4 is such that the unbalanced side thrust created acts in the plane of swing of the connecting rod B (that is, transversely to the axis of the piston pin C), against one side of the cylinder D. For clearness the curvature of the face is exaggerated in the drawing, as in practice a difference of height of the edges A^3, A^4 amounting to from 2 mm. to 5 mm. on a piston of 80 mm. diameter is usually sufficient to create the required side thrust. (*Sealed.*)

193,076. C. J. Grace, London. Carburettors. (5 *Figs.*) August 19, 1921.—The inventions relates to carburettors of the type in which fuel is delivered to an internal-combustion engine between an air-controlling throttle valve and the engine. Rotatably mounted in the carburettor body 1 and co-axial with a nozzle 3 is a plug 5 having at its upper end an actuating arm 6. The plug 5 fits over the top of the nozzle 3 and has an axial passage 7 leading to a transverse passage 8 communicating with a circumferential groove 9, see Fig. 2. Communicating with the groove 9 is a passage 10 whose inlet 11 is in communication with the atmosphere. The space between the ends of the nozzle 3 and the passage 7 constitutes a chamber 12. 13 is a diagonal slot through the wall of the chamber 12. When the arm 6 is turned, the slot 13 can be brought into or out of register with a passage 14 leading to a delivery pipe 15 located in a passage 16 formed in the carburettor body 1. The passage 16 is at one end open at 17 to the atmosphere, and at the other end communicates with an annular passage 18, which in turn communicates with delivery tubes 19 leading into the throat 20 of the carburettor. 21 is a throttle valve rotatably mounted in the carburettor body 1. 23 is a cam plate. In operation when the parts are in the position shown, that is, with the throttle valve 21 closed and the inlet ports 11 and 17 open, the velocity of the air flowing along the passage 7 and impinging against the fuel nozzle is high, and consequently the delivery of fuel from the nozzle 3 is small. The air entering through the port 11 passes at a high velocity along the passage 10, through the passage 8 and down through the axial passage 7 so as to impinge against the nozzle 3 and thus oppose and check the flow of fuel therefrom, the rate of flow being dependent upon the balance between this opposition and the negative pressure existing in the chamber 12. As the throttle valve 21 is opened, the cam plate 23 is moved to close the inlet ports 11, 17 gradually, the inlet port 11 being partly closed and the inlet port 17 partly or completely closed, when the throttle valve 21 is fully open. When the throttle valve 21 is only slightly open and the engine is idling, the port 11 is open so that the full effect of the air flowing along the passage 7 and impinging against the nozzle 3 is obtained with the result that the



delivery of fuel from the nozzle 3 is small, while the inlet port 17, being open to its fullest extent, allows air at high velocity to flow along the passage 16 past the end of the pipe 15, the resulting mixture of fuel and air passing along the passage 16, annular passage 18 and pipes 19 delivering the fuel mixture, which is atomised to a highly efficient state, into the throat 20 of the carburettor, where it mixes with the main air supply to the engine. If the mixture be found to be too rich or too weak, the amount of fuel or fuel and air passing from the chamber 12 can be regulated by rotating the arm 6 and so moving the slot 13 in the plug 5 more or less into register with the passage 14. (*Sealed.*)

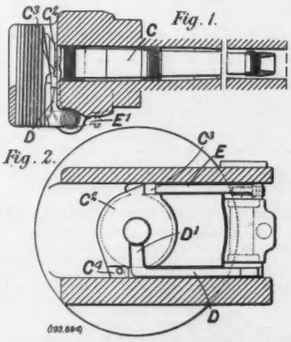
192,517. Garner Telford and Hardman, Limited, Pendleton, Salford, and J. H. Hardman, Pendleton, Salford. Charging Valves or Doors. (2 *Figs.*) November 11, 1921.—The invention relates to charging valves or doors such as are employed on furnaces, gas producers, and retorts, in which a dome or convex-shaped valve is carried on a rocking bar and held in closed position by a counterweight. According to the inven-



tion, a rotary movement is imparted to the valve or door A, as it approaches or recedes from its seat *a* to free it of any obstructing particles of fuel, by means of a train of bevel gearing E, F, G caused to revolve round a fixed wheel K, as the lever B carrying the valve or door is moved up or down. Means are also provided whereby it can be ground to its seat while in position. (*Sealed.*)

GUNS AND EXPLOSIVES.

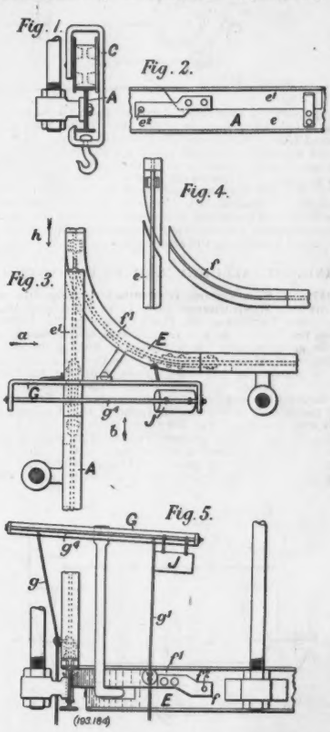
193,884. Sir A. T. Dawson, Westminster, and Sir G. T. Buckham, Westminster. Aiming Tube Adapters. (3 *Figs.*) September 6, 1921.—The invention relates to small-calibre aiming or practice tubes for use with ordnance having breech mechanism of the wedge or sliding block type. According to the



invention, the aiming or practice tube C is formed at its rear with a flange C^2, which corresponds substantially with the flange of the cartridge used in the gun itself and the flange is formed with projections C^3, C^4, which co-operate with the walls of the breech recess of the gun to prevent angular movement of the aiming tube during firing. The gun (provided with breech mechanism of the wedge or sliding-block type) is rendered suitable for the employment of the aiming or practice tube by the replacement of one of the usual extractor arms by a special extractor arm D, which has an extension D^1 of sufficient length to enable its end to engage with the flange of the cartridge of the aiming tube, and which is operated in the usual manner by the existing cam surface on the breech block, and by the replacement of the other usual extractor arm by a retaining lever E, E^1, which co-operates with a projection on the flange C^2 of the aiming tube to prevent the latter from falling out of the gun when the breech mechanism is opened with the gun at elevation. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

193,184. Lockerbie and Wilkerson (Tipton), Limited, Tipton, and J. C. Brand, Tipton. Overhead Runways. (7 *Figs.*) December 3, 1921.—The invention relates to overhead runways of the type known as joist runways, and in which the wheels of each trolley runs on the top flange. According to the invention, switches are provided and are arranged somewhat in the same manner as the switches of strip runways, that is to say, each branch of a switch has a portion pivoted to turn up about a horizontal axis to clear it from the path of the wheels of the trolley. A is a runway of girder section. C is the frame of the trolley. E represents a branch from the main portion of the runway A. At the place where the branch E joins into the main runway A both it and the main runway are divided, each at its mid-horizontal plane, into halves, and the switch member of the main runway comprises a lower fixed portion *e* and an upper portion e^1 pivoted by a hinge-piece e^2, while the switch member of the branch E comprises a lower fixed portion *f* and an upper portion f^1 pivoted by a hinge piece f^2. It will be seen that the two pivoted portions e^1, f^1 are of T-section, while the two fixed portions *e*, *f*, which may be in one piece with the main runway and the branch respectively, are of inverted T-section. The lower members *e*, *f* are clearly seen in plan in Fig. 4, while the pivoted members e^1, f^1 are clearly seen in plan in Fig. 3. The

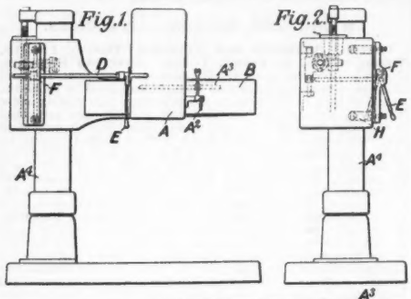


pivoted portions e^1 and f^1 are each connected by links *g*, g^1 with a rocking arm G. The rocking arm G has its ends bent at right angles (see Fig. 3) and between the ends is carried a bar g^4 upon which is adapted to slide a weight J. Extending downwards from the links *g*, g^1 are cords, and these may be provided at their lower ends with suitable handles, not shown. When one cord is pulled the pivoted portion f^1 is brought down to the position shown clearly in Fig. 5, while the pivoted portion e^1 is raised through the action of the link *g*, and the weight J at the same time assumes the position shown in Fig. 5, thus retaining the switch portions in the position to which they have been set. In this position of the switch a trolley proceeding in the direction of the arrow *h* of Fig. 3 will take the branch E and will pass under the end of the raised pivoted portion e^1. When the other cord is pulled down the pivoted portion e^1 is brought down upon its corresponding lower portion *e*, rocking the lever G to the left and causing the weight to run down to the opposite end. At the same time the link g^1 is pulled up, causing the pivoted portion f^1 to turn up about its pivot axis a sufficient distance to clear it from the path of the trolley proceeding in the direction of the arrow *h*. The trolley will now keep along the straight track A, and pass under the end of the pivoted portion f^1. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

192,563. Sir A. Herbert, Dunley Manor, near Whitchurch, and P. V. Vernon, Keresley, near Coventry. Radial Drilling Machines. (5 *Figs.*) December 31, 1921.—The invention relates to radial drilling machines of the kind in which means are provided for raising and lowering the arm by power. According to the invention, the control mechanism for the vertical movements of the arm, as well as that for clamping and unclamping it and for effecting its power movements, are operated from the drill saddle, and preferably are effected by the agency of two control members, one of which is adapted, first to unclamp the arm, and thereafter to engage the power train, a converse action disengaging the latter and reclamping the arm, while the other control member, also mounted upon the saddle, determines

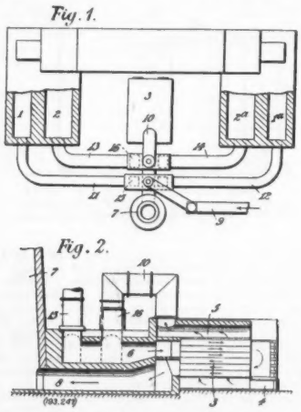
the direction of vertical movement of the arm. The drill saddle A is provided with a lever A^2 for controlling the power unit of the machine and for reversing the direction of the drive. A shaft A^3 extends parallel with the drill arm B from the reversible driving member (not shown), and provides also a drive for the drill spindle (not shown). For the purpose of the invention, the vertical movements of the arm are obtained by operatively connecting the elevating gear C, C^2, C^3 to this reversible shaft through clutch mechanism C^4. Parallel with the shaft A^3 is another shaft D, which is splined throughout its acting length



and is engaged by a hand lever E carried upon the saddle A to move the latter, the connection of the shaft D and lever E being by means of a key or feather engaging with the spline. This shaft, at the end nearest to the drill pillar A^4, by means of the gear wheel F splined upon it and mounted in the clamp cover plate G, is adapted to operate the clamp H which secures the arm B to the pillar A^4, and is so arranged that its angular movement first loosens the clamps, and thereafter, by continued motion, engages the clutch C^4, which operatively connects the elevating mechanism with the driving means, a converse action disengaging the clutch and reclamping the arm. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

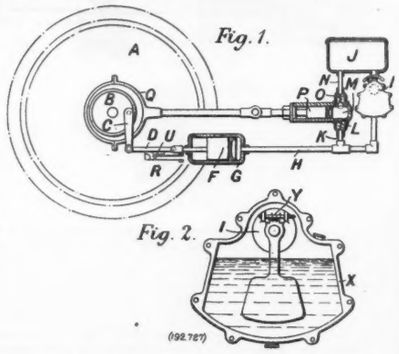
193,247. J. S. Atkinson, Westminster, Stein and Atkinson, Limited, Westminster, and J. E. Fletcher, Dudley. Regenerative Furnaces. (2 *Figs.*) January 25, 1922.—The invention has relation to gas or other fuel fired furnaces having reversible generators to which preheated air and/or gas are or is supplied, said air and/or gas being preheated in a continuously-acting recuperator by the waste gases from the regenerators. 1, 1a, 2, 2a are reversible regenerators. The regenerators 1, 1a are for heating the gas, and the regenerators 2, 2a for further heating the air. 3 is a Stein recuperator, the construction of which is such that the air or gas to be heated is caused to flow vertically without change of direction and the heating medium to flow horizontally, making one or more passes through the recuperator, the ducts or passages through which the heating medium flows being in connection or not with one another by



transverse passages or ducts. 4 is the air inlet of the recuperator 3 and 5 the outlet for the heated air. The regenerators 1, 1a, 2, 2a are in communication at their upper ends with the furnace as usual, and the lower ends of the several regenerators are in connection by ducts 11, 12, 13, 14 with the waste gas culvert 6, which is in connection indirectly with the chimney 7 through the horizontal passages or ducts of the recuperator 3 and a flue 8. 15 is a reversing valve at the junction of the ducts 11, 12, and 16 is a reversing valve at the junction of the ducts 13, 14. 9 is the gas supply pipe, and 10 is a pipe in connection with the outlet 5 of the recuperator. The pipes 9, 10 are in connection with the ducts 11, 12, 13 and 14, respectively, and their connection each with one of the ducts, say 11 and 13 or 12 and 14, and the connection of the other ducts, say 12 and 14, or 11 and 13 with the waste gas culvert 6, is controlled by the reversing valves 15, 16, respectively. (*Sealed.*)

MOTOR ROAD VEHICLES.

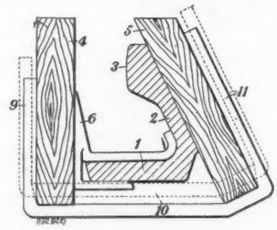
192,727. R. W. Tarrant, London, and Regan Safety Devices, Limited, London. Automatic Speed-Controlling Device. (2 *Figs.*) October 10, 1921.—The invention relates to speed-controlling devices for mechanically-driven road vehicles of the type in which a force pump operating at a rate corresponding to the rate of travel of the vehicle, forces liquid to a ram, and also to an adjustable by-pass, so that the ram is only moved when the rate exceeds that at which the liquid can escape through the by-pass. According to the invention, the apparatus is arranged so that a braking effect takes place at all times on the defined speed being exceeded, the defined speed varying according to the gradient on which the vehicle is travelling. The essential parts of the apparatus consist of an oil or other fluid pump operated from the road wheels, or from the transmission shaft, or from any convenient mechanism from a moving part of the vehicle so that the action of the pump corresponds to the speed of travel, a by-pass, a ram to be operated by the oil or other fluid forced into the system by the pump in excess of that which can escape through the by-pass, and a pendulum or gravity device for varying the by-pass according to the gradient. A is one of the driving wheels of the vehicle and B a brake drum thereon. C is a lever arm, the movement of which controls the brake (not shown). The lever C is connected to a pump ram F in the cylinder G. A pipe H leads from the cylinder G through an adjustable by-pass I to the oil reservoir J, and a branch K from pipe H containing the valve L connects with the pump cylinder M.



A pipe N leads past a suction valve O from the reservoir J to the pump cylinder M. The piston P in the cylinder M is constantly driven by an eccentric Q from the wheel A. Adjacent to the rod D is a switch R comprising a leaf spring adapted to be deflected by an inclined plane U on the rod D when the brake is applied by this device, thus breaking the ignition circuit in which this switch is placed. It will be seen that when the predetermined speed is not exceeded, the pump strokes will deliver a relatively small amount of oil per unit of time and this will pass back to the reservoir by the by-pass I, but if the speed increases to an extent which causes the pump to deliver a larger quantity of oil per unit of time than can flow past the by-pass I, the excess of oil will move the ram F against the counter-force of the brake releasing spring, and so cause the brakes to be applied and at the same time, by opening the switch R, cause the ignition circuit to be broken. The device used to govern the position of the by-pass I comprises a pendulum W on the cock of the by-pass, moving in casing X filled with oil. The angular position of the pendulum in relation to the cock is adjustable by means of a screw Y. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

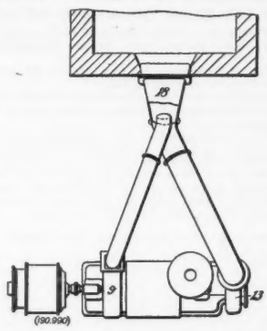
192,922. G. Ellson, Purley, and the South-Eastern and Chatham Railway Companies Managing Committee, London Bridge. Live Rails or Conductors. (1 *Fig.*) February 8, 1922.—The invention has relation to the protection of the live rails or conductors in systems of electric traction. Protective means for the live rails or conductors in systems of electric traction comprise, in accordance with the invention, plane boards 4, 5 disposed on opposite sides of the rail or conductor 2, with one board 5 sloping downwardly and outwardly and the other, 4, disposed vertically or approximately so, and "U" shaped clamps, the horizontal members 10 of each of which extend below the rail or conductor 2, and one arm 11 of each of which inclines inwardly and bears directly against the outer face



of the sloping board 5, and the other arm 9 of each of which contacts directly with the outer face of the vertical, or approximately vertical, board 4. Further, in connection with such protective means, the live rails or conductors 2 are of "L" shape in section with the arms disposed at an acute angle and the outer face of the upwardly-extending and inwardly-inclined arm contacting with the inner face of the sloping board 5. The upper end of the inclined arm has a surface 3 on its inner face with which the collector shoe contacts. Clips or clamps 6 are mounted on the horizontal member 1 of the live rail or conductor 2, and these each have a vertical, or approximately vertical, member, the outer face of which, when in position, contacts with the inner face of the vertical, or approximately vertical, board 4. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

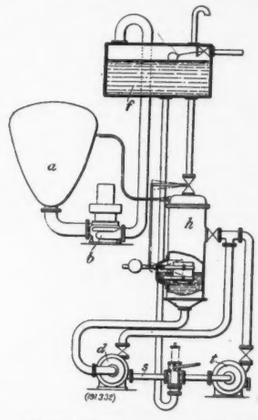
190,990. The Powdered Fuel Plant Company, Limited, Westminster (*the Assignees of La Combustion Rationelle* (*Société Anonyme*), *Paris, France*). **Powdered Fuel Combustion.** (2 *Figs.*) March 6, 1922.—The invention relates to apparatus for pulverising coal and other substances of the kind in which the coal is converted into a powdered or pulverulent condition by impactors which are contained within a closed casing and are mounted on, and are arranged circularly in relation to, a shaft that is carried in bearings at the ends of the casing and is driven at a high speed. The powdered product is extracted from the casing by the passage of a current of air through the closed casing, the coarseness or fineness of the powdered product depending on the velocity and volume of air propelled by a fan through the casing which is usually designed to supply all the air necessary for the full and complete combustion of the fuel supplied thereby. The pulverising apparatus according to the invention has independent fans, one for primary or conveying air which enters the pulveriser casing at the end remote from the fan, and which entrains powdered fuel and carries it forward, and the other for secondary air, which is drawn directly from the atmosphere and



supplies the additional air necessary for the full and complete combustion of the fuel conveyed by the primary air, and the characteristic feature of the invention resides in the fact that the outlets of the fans 9, 13 are connected independently and directly to the burner 18. 9 is the primary air fan which is situated at one end of the casing. (*Sealed.*)

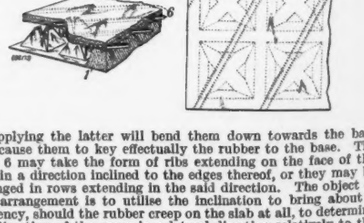
MISCELLANEOUS.

191,332. G. and J. Weir, Limited, Cathcart, Glasgow, and the Right Hon. W. Douglas, Baron Weir, Eastwood. Steam Power Station Systems. (1 *Fig.*) May 31, 1922.—The invention relates to steam-condensing and feed-water systems for steam power stations. The invention is applicable to a steam condensing plant and feed-water system for power stations which comprises a main condenser *a*, an atmospheric feed tank *f*, a water condensate extraction pump *b*, which withdraws the condensate from the condenser *a* and delivers it into the feed tank *f*, a feed pump *t* for delivering the feed water to the boilers, a booster pump *d*, and a direct contact feed heater *h*. The arrangement of the system, according to the invention,



involves and is characterised by the location of the heater *h* between the feed tank *f* and the booster pump *d*, the maintenance of a vacuum in the heater *h* corresponding to the feed temperature and the liberation of the air and non-condensible gases in the feed water in the heater, and the delivery of the air-free water by the booster pump *d* through a closed pipe *s* under pressure to the feed pump *t*. When the heater is of the direct contact type the feed water within it may be heated by steam from an auxiliary exhaust range. The liberated gases are withdrawn from the heater, it may be by the suction action of the condenser acting through a pipe of small bore connecting the heater and condenser or it may be by an independent pump or by a steam jet air ejector. (*Sealed.*)

192,175. R. H. Rogers, London. Paving Blocks. (2 *Figs.*) October 29, 1921.—The invention relates to paving slabs. According to the invention, there is provided a paving slab comprising a reinforced concrete base-portion 1 from whose upper surface keys 6 of sheet metal project and a rubber facing applied to the said upper surface so as to be engaged by the keys 6, the keys being inclined to the face of the slab prior to the application of the rubber so that pressure during the process



of applying the latter will bend them down towards the base and cause them to key effectually the rubber to the base. The keys 6 may take the form of ribs extending on the face of the slab in a direction inclined to the edges thereof, or they may be arranged in rows extending in the said direction. The object of this arrangement is to utilise the inclination to bring about a tendency, should the rubber creep on the slab at all, to determine the direction of the creep in a lateral direction relatively to the roadway. (*Sealed.*)